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ABSTRACT

This second section of a three-part syllabus for a flexible curriculum in trade electricity-electronics contains four semi-independent units: (1) Advanced Electricity, (2) Residential and Commercial Wiring, (3) Industrial Electricity, and (4) Motor Controls. Introductory sections describe development of the curriculum, outline the total trade electricty-electronic program, and provide suggestions to teachers on use of the syllabus. The four units are intended to be used separately or arranged in various sequences to meet the needs of individual students and area employment markets. Units are organized in a three-column format: outline of content, student objectives, and teaching suggestions. At the end of each unit is a list of resources with the following categories: books for teacher reference, books for student reference, periodicals, films-filmstrips, and transparencies. Also included for each unit is a list of tools and equipment considered essential to instruct a class-group of twenty students. (Section I--Basic Electricity is available separately, a unit six to ten weeks to develop competencies necessary to all electricity or electronics employment. Section III, being developed, covers trade electronics.) (JT)

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SYLLABUS IN TRADE ELECTRICITY-ELECTRONICS

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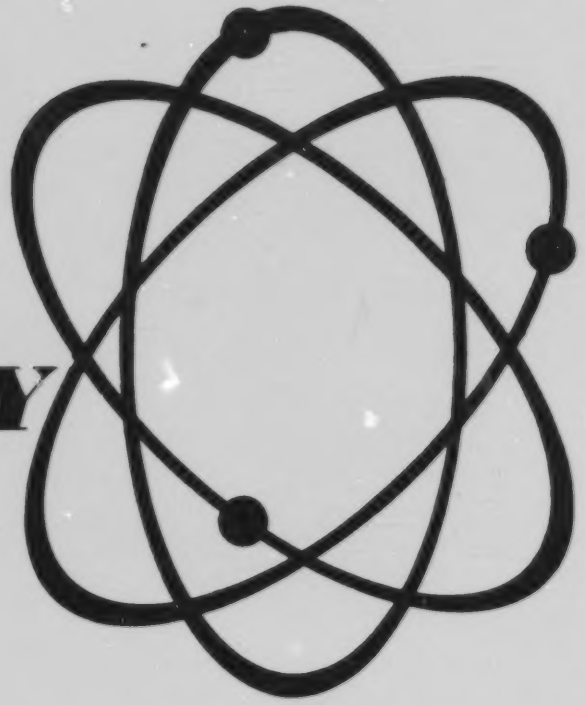
SECTION II —

TRADE ELECTRICITY



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THE UNIVERSITY OF THE STATE OF NEW YORK/THE STATE EDUCATION DEPARTMENT
BUREAU OF OCCUPATIONAL EDUCATION CURRICULUM DEVELOPMENT /ALBANY, NEW YORK 12234

1977

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SYLLABUS IN TRADE ELECTRICITY-ELECTRONICS

SECTION II —

TRADE ELECTRICITY

The University of The State of New York/The State Education Department
Bureau of Occupational Education Curriculum Development/Albany, New York 12234
1977

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FOREWORD

In 1972 an experimental syllabus for a core course in trade electricity-electronics was distributed to the field. Feedback from teachers and administrators, individually and through workshops, provided desired recommendations for revision. In August 1974, a committee consisting of teachers of the subject, Blake Bayly of Albany-Schenectady-Schoharie BOCES, Roy Bloom of Nassau BOCES, and Edward Chauvin of Dutchess BOCES, met with Joseph J. Messier, Associate in Vocational Curriculum, and Charles A. Stebbins, Associate in Industrial Education, to effect changes in the curriculum. A three-section, eleven-module content outline was produced.

At a subsequent meeting of the Directors, Divisions of Curriculum Development, Occupational Education Instruction, and Occupational Education Supervision, the Chief of the Bureau of Trade and Technical Education, and the Supervisor of the then Vocational Curriculum Unit, it was decided to develop the content outline through grants to selected local education agencies. A proposal submitted by Orange County BOCES, acting as agent for Orange, Rockland, and Ulster BOCES, to develop a syllabus and sample course of study for the basic electricity section of the content outline, was accepted. The resulting *Section I - Basic Electricity*, of the *Syllabus in Trade Electricty-Electronics*, was distributed in October of 1976. Meanwhile grants had been made for development of the modules of *Section II - Trade Electricity*. Under supervision of Mr. Messier, the project director, two teacher-committees were convened to develop this section of the syllabus.

In the summer of 1975, Evan Lougher of Livingston-Steuben-Wyoming BOCES coordinated the efforts of Robert N. Bush, Genesee-Wyoming BOCES, Frank S. DiSalvo, Livingston-Steuben-Wyoming BOCES, Donald E. Forman and John G. Robinson, Monroe BOCES #1, Theodore G. Kuntz, Monroe BOCES #2, and Gerald E. Reed, Wayne BOCES, in development of manuscripts for *Industrial Electricity* and *Residential and Commercial Wiring*. During the spring and fall of 1976, Harold Dworetzky, Curriculum Coordinator, Orange BOCES, supervised the development of *Advanced Electricity* and *Motor Controls*, by Parker A. Black, Ulster BOCES, Edward A. Chauvin, Dutchess BOCES, Oliver H. Clark, Westchester BOCES #2, William P. Fleischauer, Westchester BOCES #1, and Irving Fox, Orange BOCES.

The manuscripts, prepared for publication by Mr. Messier, were reviewed by Richard Barnwell, Associate, Bureau of Trade and Technical Education before being printed and distributed.

Section III - Trade Electronics, now under development, will be distributed to complete this occupational education syllabus.

G. Earl Hay, *Chief*
Bureau of Occupational Education
Curriculum Development

TO THE TEACHER

The *Syllabus in Trade Electricity-Electronics* is a new, highly flexible curriculum organized in three parts: *Section I — Basic Electricity, Section II — Trade Electricity,* and *Section III — Trade Electronics.*

Section I is a unit of 6-to 10-weeks duration which develops only those competencies necessary to all electricity or electronics employment. Each student must possess these competencies before choosing specialization areas of electricity or electronics for continued study. Since these basic competencies are not entry-level skills, course credit can not be granted for completion of this unit alone. It is necessary for each student to attain the objectives of one or more of the units of *Section II* or *Section III* also, to receive credits for this study. Further, State credit toward the diploma is based on time as well as content. A maximum of two credits may be granted for one year of 160 teaching days of 2½ hours each. Two such academic years of study of trade electricity-electronics will satisfy the requirements for a Group II sequence as outlined in *The Secondary School Curriculum of New York State — A Handbook for Administrators.* When a local program of instruction conforms to this syllabus, approval to grant State credit is presumed. Only where there is reason to adopt a nonconforming course of study must copy of the course be submitted to the Bureau of Occupational Education Curriculum Development toward specific approval.

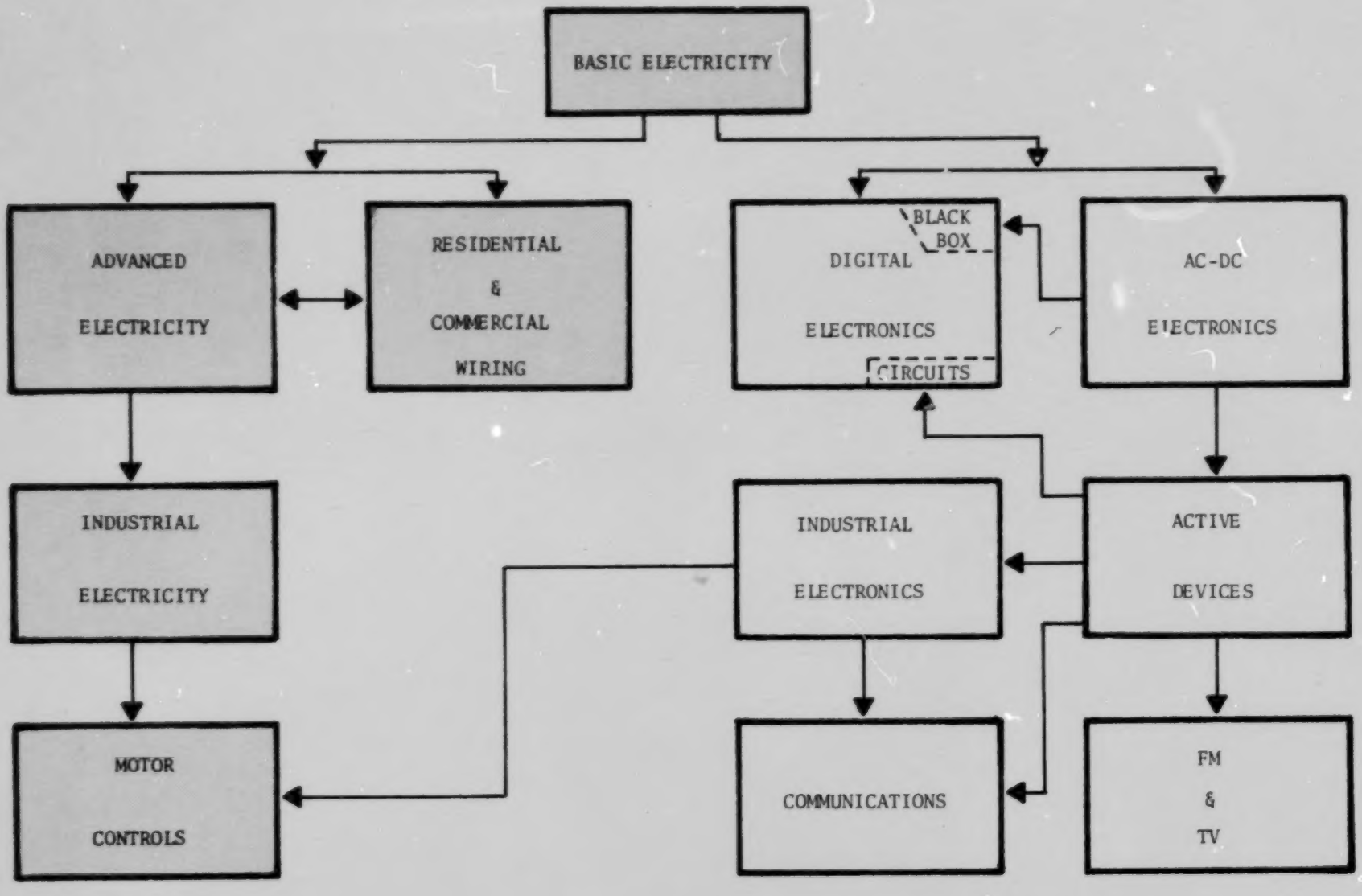
Evidently, in a student-centered, self-paced program, some students will complete only one of the specialization areas, many will complete two, and some will complete three or more in addition to *Section I.* The breadth of achievement should be noted in each student's records.

It is expected that national conversion to metric measurement will be accomplished within the projected life of this syllabus. While most electrical measurement will remain in the familiar units — amps, volts, ohms — the units of physical measurement, and electrical measurements based thereon, will change. Although references to measurement in the syllabus are stated in units of the system in use at the time of printing, the teacher should plan to introduce the metric system so that students completing the course will be prepared for this change in employment competency.

Carl G. Benenati, *Chief*
Bureau of Trade and Technical Education

FLOW CHART

TRADE ELECTRICITY-ELECTRONICS PROGRAM



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SYLLABUS IN TRADE ELECTRICITY-ELECTRONICS

SECTION II — TRADE ELECTRICITY

UNIT I: ADVANCED ELECTRICITY

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USING THE SYLLABUS

Although bound as one volume, the four units of the syllabus which comprise *Section II — Trade Electricity*, are semi-independent. They may, as indicated by the flow chart, be arranged in various sequences to meet the needs of the individual student and the area employment market. The publication is constructed so that units may be separated; those not offered in the school's program of instruction in trade electricity-electronics being placed at the back of a ring-binder.

The content of each unit represents the minimum which should be taught in a broad but specific instructional area. It is expected that each teacher, with the aid of the advisory council and curriculum coordinator, will add to the depth and breadth of the contents whatever is needed for entry-level employment while developing a course of study based on the syllabus. To assist the teacher in this process, the units are organized in a three-column format — content, objectives, and teaching suggestions — with a resource list and suggested equipment list appended.

The first column lists content organized in a logical, though not necessarily teaching, sequence. The first task in developing a course of study based on the syllabus is to reorganize the content sequence into that which should be most effective. While some content naturally flows from and to other specific content, many items can be "shuffled" to fit the student's extant motivation and readiness.

The middle column contains the objectives of the content, expressed in terms of desired student performance. In industry, the competent worker, given an apprentice or new worker to train, judges both the development of the learner and the effectiveness of the instruction by whether the learner can perform the particular task. In teaching trade electricity, the industrially experienced teacher will instinctively use the same performance criteria in evaluating student progress. He should also use it as a guide to selecting probably successful teaching methods. The teacher should, then, write performance objectives for the course of study which clearly and concisely state *what* he intends to teach *before* developing lesson plans which state *how* he intends to do so.

The third column consists of suggested methods of teaching the content to attain the stated objectives. This listing is not to be considered as prescriptive; it is included to demonstrate the variety of methods available, and so, stimulate the individual teacher's ingenuity in employing various methods tailored to each of his various students.

The resulting course of study will need revision only as changes occur in the skills and knowledge required for entry into employment in the specialization studied. As such it serves as a basis for the lesson plans which must be continuously revised in order to provide each student with quality instruction.

Upon completion of this unit the student will be able to demonstrate the knowledge of electrical theory and practice necessary to calculate voltage and power in AC circuits; maintain and use electrical measuring devices; plot phase relationships; analyze effect of reactance in AC circuits; calculate and use inductors and capacitors; construct a resonant circuit of specified frequency and predetermine values of total current with respect to frequency; determine selection of and connect various single-phase and polyphase transformers; connect various AC and DC generators; and connect, test, and maintain various electric motors.

CONTENT	OBJECTIVES	TEACHING SUGGESTIONS
MEASUREMENT		
• Voltage and Current	*The student should be able to:*	
— rms	Define effective or rms values of alternating current and voltage.	Review wiring diagram and schematic symbols. Demonstrate use of the oscilloscope to measure known peak voltage. Demonstrate use of the VOM to measure the same voltage. Draw sine waves indicating Pk and rms voltages. Explain rms values of AC in respect to heating effect of DC.
	Solve problems by use of formulas.	Have students solve problems mathematically.

• Voltage		
— Peak-to-peak	Solve problems for peak-to-peak voltage when given rms values.	Demonstrate use of oscilloscope to show peak-to-peak voltage.
	Define peak-to-peak values of alternating current and voltage.	Use a galvanometer and hand-operated generator to show values in two directions.
		Have students solve problems mathematically.
• Power		
— Single-phase	Use power formulas.	Interpolate power formulas.
		Demonstrate the connecting of a wattmeter in a single-phase circuit.
		Emphasize power as positive at all times.
		Have students draw a power wave, given voltage and current values.
		Have students solve problems mathematically.
— Polyphase	Calculate power in delta and wye circuits, by use of formulas.	Demonstrate the connecting of a wattmeter in a polyphase circuit.
		Have students solve problems mathematically.
• Power Factor		
— True power	Define "true power."	Explain power factor and the correction thereof.
	Measure true power in an AC circuit.	

CONTENT	OBJECTIVES	TEACHING SUGGESTIONS
	The student should be able to:	
— Apparent power	Define "apparent power" and "reactive power."	Construct a vector drawing of true, apparent, and reactive power.
	Cite the difference between watts, volts, amps, and ohms, and relate each to its proper use.	Demonstrate the measurement of volts and amps in an AC circuit.
— Determination	Relate true power to apparent power, to determine power factor.	
	Solve problems using the square root formula.	Distribute information sheets containing power factor diagrams and sample calculations.
· Low factor	Calculate and describe the effects of low power factor.	$W = I^2R$
· Correction	Explain power factor correction by installation of: synchronous motors capacitor, or bank of capacitors	Introduce power factor correction tables. Have students solve problems using the tables.
PHASE RELATIONSHIP		Overhead projection should be a useful method.
◦ In-Phase	Define in-phase, phase angle, and phase shift.	Demonstrate the use of a dual-trace oscilloscope to show phase relationship.
	Plot on graph paper a phase and time relation, using vector representation of a resistive load circuit.	Have students solve problems mathematically.
◦ Out-of-Phase		
— Lagging	Define out-of-phase: lagging.	Use the oscilloscope to show phase relationship.

	Plot on graph paper a phase and time relationship using vector representation of an inductive load circuit.	Have students solve problems mathematically.
— Leading	Define out-of-phase: leading.	Use the oscilloscope to show phase relationship.
	Plot on graph paper a phase and time relationship using vector representation of a capacitive load circuit.	Have students solve problems mathematically.
REACTANCE		
• Inductive	Calculate the effect of inductance on current in a DC and AC circuit.	Use a reactive series light circuit to visually demonstrate the effect of inductance in a lighting circuit.
		Schedule a field trip to a theater to see backstage lighting.
$X_L=2\pi FL$	Solve numerical problems by use of the formula for inductive reactance.	Illustrate the phase relations between voltage and current in an inductive circuit.
		Use the dual trace oscilloscope to show phase relationship. Have students solve problems mathematically.
• Capacitive	Calculate the effect of capacitance on current in a DC and AC circuit.	Illustrate the phase relations between voltage and current in a capacitive circuit.
	Determine the reactance of a capacitor.	
$X_C=\frac{1}{2\pi FC}$	Solve numerical problems by use of the formula for capacitive reactance.	Have students solve problems mathematically.
• Frequency Effect	Numerically calculate the effect of frequency on inductive and capacitive circuits.	

CONTENT	OBJECTIVES	TEACHING SUGGESTIONS
INDUCTANCE	*The student should be able to:*	
◦ Calculation	Define and use the units of measurement of inductance, and identify ASA and NEMA wiring symbols.	Have students solve problems involving measurement and reading diagrams.
— Henry		
— Millihenry	Calculate the impedance of series and parallel connected inductors.	Demonstrate use of the impedance triangle.
— Microhenry		Demonstrate the effects of inductors connected in series and parallel circuits.
◦ Types of Inductor	List and identify the types of inductor.	Show and state the uses of the types of inductor.
— Iron core		Demonstrate the comparison of loads.
— Air core		
— Powder core		
◦ Application	List the uses of inductors in common circuits.	
— Waveform smoothing	Connect inductors in series, parallel, and series-parallel configurations.	Demonstrate connections.
— Opposition of AC and passing DC		Have students solve problems mathematically.
— Ballast in lighting circuits		
— Motor speed control		
CAPACITANCE		
◦ Calculation	Define and use the units of measurement of capacitance.	Demonstrate the effects of various surface areas of the plates and

— Farad — Microfarad — Picofarad	Calculate the value of a capacitor. Calculate series-parallel connected capacitors for the total value in a circuit.	thicknesses of the dielectric, using the formula — $C = \frac{0.0885 \times K \times A}{T}$ Demonstrate the effects of series-parallel connected capacitors. Have students solve problems mathematically.
◦ Application — Wave shaping — Bypass for AC — Other	Describe the common practical uses of capacitors.	
RLC SERIES CIRCUITS		
◦ Impedance	Construct an AC circuit, given resistors, coils, and capacitors, and their values. Compute the total resistance (impedance) of the constructed circuit. Use the impedance triangle to solve problems.	Review the effects of alternating current on coils and capacitors. Construct the circuit which the students will make. Demonstrate the total effect on the circuit when the loads are connected in series to an AC source. Review the impedance triangle.
◦ Resonance	Determine what constitutes a resonant series circuit.	Demonstrate a simple resonant series circuit, showing the increase in current at resonant frequencies. Explain the uses of resonant circuits in industry.

CONTENT	OBJECTIVES	TEACHING SUGGESTIONS
RLC PARALLEL CIRCUITS		
	The student should be able to:	
◦ Impedance	Construct a parallel circuit, given resistors, capacitors, and inductors, and their values.	Compare a resistive parallel circuit, and a parallel circuit having capacitance and inductance.
	Calculate the total current and impedance of the constructed circuit when connected to an AC source of specified frequency.	Demonstrate the use of the current triangle to solve problems.
	Compute the total current in a parallel circuit by use of the current triangle.	Illustrate the plotting of vectors to determine phase angle and addition of out-of-phase currents.
	Compute phase angle in a parallel circuit by use of the current triangle.	
◦ Anti-Resonance	Determine what constitutes an anti-resonant circuit.	Review the resonant circuit (series) and compare with the anti-resonant circuit (parallel).
		Use vectors and a current triangle to demonstrate the position of phase angle in an anti-resonant circuit.
		Explain the uses of anti-resonant circuits in industry.
TRANSFORMERS		
◦ Principles of Operation		
— Ratios	Calculate voltage, current, turns ratio, and power in a transformer.	Demonstrate the effects of a transformer in a circuit, by measuring voltages and current.

		Review wiring symbols and transformer diagrams (overhead projection should be effective).
		Have students solve problems mathematically.
— Ratings	Interpret information provided on transformer nameplates.	Show various size transformers and indicate the nameplate ratings. Project a transparency of a nameplate.
	Calculate transformer capacity.	Have students solve problems mathematically.
— Polarity	Define additive and subtractive polarity.	Demonstrate the DC method of determining polarities in a transformer. Use diagrams to illustrate the principles of operation.
		Demonstrate series and parallel connections on a multitap transformer.
— Types		
· Isolation	Describe the characteristics of iron core and air core transformers.	A field trip to the school power plant, or a public utility station, should be instructive.
· Autotransformer	Describe the characteristics of the autotransformer.	
	Describe the similarities and differences of conventional isolation transformers and autotransformers.	Describe uses of iron core, air core, and autotransformers.
	Sketch and identify the coils in an autotransformer.	Demonstrate the connection of and voltages in an autotransformer, noting its hazards.
	Identify and connect an autotransformer.	

CONTENT	OBJECTIVES	TEACHING SUGGESTIONS
• Construction		
	The student should be able to:	
— Core	List, describe, and identify the various transformer cores.	Use diagrams of various core constructions and cutaway views of transformers.
	State the reasons for using laminated construction in transformers.	Display an air core transformer; a metal core transformer.
— Windings	Describe the methods of construction of primary and secondary windings.	Use cutaway view of transformer as reference, and diagrams to illustrate windings construction.
	Determine mathematically the size wire appropriate to a given transformer application.	
— Insulation	List materials used as insulation in transformer construction.	Show, and explain, some examples of the types of insulation used in transformers.
	Test for insulation failure in transformers.	Explain effects of heat and impurities in air and oil transformers.
		Demonstrate use of the megger.
— Cooling	Identify and describe methods of cooling transformers.	Show illustrations of types of transformers.
		Emphasize necessity of cleanliness and carefulness when working with large transformers.
		Review importance of purity of insulating oil.
	Describe methods of monitoring heating.	Illustrate methods of monitoring heating effects.

		A field trip to a transformer yard, to enable first-hand viewing, should be effective.
— Wiring		
· Standard markings	Identify the high voltage and low voltage terminals on a transformer.	Show a clearly marked transformer.
· Connection	Make connection to transformer windings.	Connect a multi-coil transformer for several different primary and secondary voltages.
		Demonstrate connections.
Wye	Solve problems of voltage and current relationships in wye connected transformers.	Show illustrations of wiring connections of a wye connected transformer.
	Connect three single-phase transformers in wye.	Explain voltage and current relationships in a wye connected transformer.
		Have students solve problems mathematically.
Delta	Sketch the coil connections in a delta connected transformer.	Distribute drawings of wiring connections of a delta connected transformer.
	Describe voltage and current relationships in delta connected transformers.	Explain current and voltage relationships in a delta connected transformer.
	Connect three single-phase transformers in delta.	Solve problems by use of formula.
		Connect three single-phase transformers in delta, and show current readings.
Open delta	Connect two single-phase transformers in open delta.	Demonstrate open delta connection of two single-phase transformers.

CONTENT	OBJECTIVES	TEACHING SUGGESTIONS
	The student should be able to: Determine the capacity of open delta connection in comparison to closed delta connection.	Have students solve problems by use of open delta formulas: .58 x total KVA .865 x total of 2
GENERATORS		
◦ Principles of Operation	Explain the magnetic principles involved in generator action.	Overhead projection of illustrations is an effective method.
— Fleming	Explain Fleming's rule for generators.	
— Lenz	Explain Lenz's law pertaining to generators.	
◦ Types		
— DC	Describe the operating characteristics of DC generators.	Demonstrate the operation of the DC generators.
· Separately excited · Shunt wound · Compound wound	Identify by type, sample DC generators.	Project transparencies of important features of the DC generators.
— AC	Describe the operating characteristics of AC generators.	Demonstrate the operation of the AC generators.
· Rotating armature · Rotating field	Identify, by type, sample AC generators.	Project transparencies of important features of the AC generators.
◦ Wiring Connection		
— DC		
· Shunt	Connect the components of a shunt wired generator.	Demonstrate connections of a shunt wired generator, emphasizing polarity. Show the voltage output.

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		Project transparencies to augment the demonstration.
· Compound	Connect the components of compound wired generators.	Demonstrate connections of compound wired generators as: flat-compounded over-compounded under-compounded
— AC		
· Single-phase	Connect the components of a single-phase alternator.	Demonstrate the connections of single-phase alternators and poly-phase alternators.
· Polyphase	Connect the components of polyphase alternators.	Project transparencies to augment the demonstration.
— Multiple units		
· Parallel operation	List and explain the reasons for paralleling generators.	Demonstrate connections, emphasizing the importance of: instantaneous voltage phase rotation frequency
· Synchronization	Connect and synchronize multiple generator units.	Demonstrate use of synchronizing lights and/or synchronoscope.
MOTORS		
◦ Principles of Operation	Describe the operating principles of motor action.	Be sure that students fully understand such terms as induction, capacitance, starting current, running current, back EMF, squirrel cage, rotating magnetic field, transformer action, and locked rotor.
— Fleming's Rule	Explain Fleming's rule for motors.	
— Lenz's Law	Explain Lenz's law pertaining to motors.	

CONTENT	OBJECTIVES	TEACHING SUGGESTIONS
◦ Types		
	The student should be able to:	
— DC	Identify, by type, sample DC motors. Describe the common uses of each type.	Project transparencies of diagrams, illustrations of motor components, and sketches of terminal connections.
· Shunt	Explain the operational characteristics of shunt motors.	Be sure that students fully understand such terms as speed regulation, speed control, field flux, torque, and shunt coil.
· Series	Explain the operational characteristics of series motors.	Be sure that the students fully understand such terms as armature reaction, and series coil. Emphasize the importance of operating this motor *only* when under load.
· Compound	Explain the operational characteristics of compound motors.	
— AC	Identify, by type, sample AC motors. Describe the common uses of each type.	Project transparencies of diagrams, illustrations of motor components, and sketches of terminal connections.
· Three-phase squirrel cage induction	Explain the operational characteristics of three-phase induction motors.	Be sure that the students fully understand such terms as slip, speed, stator, rotor, poles, air gap, and horsepower.
	Calculate the synchronous and rotor speed of three-phase induction motors.	Have students solve problems mathematically.
· Three-phase wound rotor	Explain the operational characteristics of three-phase wound rotor motors.	Be sure that the students fully understand such terms as slip rings, starting torque, external resistance, brushes, and external control.

· Three-phase synchronous	Explain the operational characteristics of three-phase synchronous motors.	Be sure that the students fully understand such terms as synchronous capacitor, synchronized, and external power sources.
· Split-phase	Explain the operational characteristics of split-phase motors.	Be sure that the students fully understand such terms as start windings, run windings, potential relay, current relay, Klixon switch and centrifugal switch, start capacitor and run capacitor.
· Split-phase capacitor	Explain the operational characteristics of split-phase capacitor motors.	
· Repulsion	Explain the operational characteristics of repulsion motors.	Be sure that the students fully understand such terms as necklace, short circuiting, and brush lifting.
· Universal	Explain the operational characteristics of universal motors.	Be sure that the students fully understand such terms as armature reaction and compensating windings.
· Shaded pole	Explain the operational characteristics of shaded pole motors.	Be sure that the students fully understand such terms as shading coil, synchronous speed, and rotor poles.
· Selsyn units	Explain the operational characteristics of selsyn motor units.	Be sure that the students fully understand such terms as damping, transmitter (master) and receiver (slave), and differential.
MOTOR AND GENERATOR MAINTENANCE		
◦ Mechanical Components		
— Bearings	Clean and lubricate bearings in conformance with manufacturer's specifications.	Review the various types of bearings and maintenance procedures required for each. Emphasize the importance of cleanliness. Display various types of bearings.

CONTENT	OBJECTIVES	TEACHING SUGGESTIONS
		Demonstrate the maintenance procedures — cleaning and lubricating with the specified lubricant only — for each.
		Emphasize the importance of using only the specified amount of lubricants.
	The student should be able to:	
— Switches	Determine the condition of centrifugal switches.	Demonstrate procedure for checking centrifugal switches.
		Describe motor symptoms of a faulty switch.
	Replace defective centrifugal switches.	Demonstrate replacement of a centrifugal switch.
— Governors	Determine whether governor devices are operating to standards.	Display various governors used on split-phase and repulsion motors. Demonstrate correct and faulty operation, and the checking procedure.
◦ Electrical Component Testing		
— "Meggers"	Measure insulation resistance by use of a "megger."	Demonstrate operation and use of a megohmmeter. Compare use with that of ohmmeter.
— "Growlers"	Test an armature for shorts and opens by use of a "growler."	Demonstrate operation and use of a "growler."
	Test stator coils for shorts and opens by use of a "growler."	Describe the transformer action of both the internal and the armature types of "growlers."
	Test stator coils for shorts and opens by use of an "internal growler."	

— Capacitor testers	Test capacitors for leaks, opens, and required capacity by use of a capacity tester.	Review capacitor construction, describing how capacity is determined. Project transparencies of illustrations of tester construction.
— Ammeters	Determine phase balance of a three-phase motor by use of an ammeter.	Review use of ammeters. Review operation of three-phase motors. Demonstrate the use of the ammeter to determine phase balance.
◦ Operating Unit Testing		
— "Prony brake"	Measure torque using a "prony brake."	Review torque measurement. Develop a demonstration to illustrate the principle of brake horsepower. Review the formula: 1 HP = 33,000 ft. lbs./min. HP = .00019 x torque x RPM
	Describe the faulty conditions indicated by low torque.	Show how broken rotor bars would reduce torque.
— Tachometer	Determine the RPM of a motor by use of a tachometer.	Review motor operation and slip. Demonstrate use of the tachometer to determine RPM.
	Describe the faulty conditions which might be indicated by reduced RPM.	Show how broken rotor bars would increase slip and reduce RPM.
METERS		
◦ Principles of Operation	Identify types of meter movements, and describe their principles.	Display and discuss the various meter movements.

CONTENT	OBJECTIVES	TEACHING SUGGESTIONS
— D'Arsonval — Iron vane — Hot wire — VTVM — Solenoid		Project transparencies of illustrations of their features.
	The student should be able to: Expand meter range by use of resistors selected by formula calculations.	Demonstrate the calculation of sensitivity, internal resistance, and external resistance. Have students solve problems mathematically.
◦ Use — Voltmeter — Ammeter · Current transformer · In-line — Ohmmeter — VOM — VTVM — Wattmeter — Watthour meter	Select the type meter for determing voltage, amperage, power, energy, resistance, and continuity. Use each type meter in conformance with field standards of safety, efficiency, and accuracy.	Distribute hand-out sheets listing the various meters and appropriate uses of each, and cautionary statements regarding inherent limitations.

BOOKS

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Loper, Orla & Ahr, Arthur. *Introduction to electricity and electronics*. Albany, NY. Delmar Publishers. 1973.

National Fire Protection Association. *National electrical code*. Boston. The Association. 1975.

PERIODICALS

Electrical Construction & Maintenance. McGraw-Hill. P.O. Box 510, Hightstown, NJ. 08520

Popular Electronics. 434 South Wabash Avenue, Chicago, IL. 60605

School Shop. 416 Longshore Drive, Ann Arbor, MI. 48107.

Servicing. Howard W. Sams & Co. 4300 West 62d Street, Indianapolis, IN 46206.

FILMS-FILMSTRIPS

National Electrical Association. 470 Atlantic Avenue, Boston, MA. 02210.

The electrician.

University of Illinois, Division of University Extension. Champaign, IL. 61820.

Electrical circuit faults; #51358

Electrical measurement; #58800

Electricity and magnetism — electric motors; #80832

TRANSPARENCIES

Keuffel and Esser Co., Educational Audio Division, 300 Adams Street, Hoboken, NJ 07030.

Alternating current (sinewave)

3-M Business Products Sales, Inc., 141 East Main Street, Elmsford, NY 10523.

Electricity & Motors

TOOLS AND EQUIPMENT

This listing contains only the tools and equipment considered essential to properly instruct a class-group of 20 students in *Advanced Electricity*. Items essential to other units of the trade electricity-electronics program, or useful but not essential to this unit, are not included. Items listed here which are also listed for other units should not be duplicated in the school supply unless the respective units are to be taught concurrently to different class-groups. Class-groups of more than 20 students will, of course, require a corresponding increase in the quantities suggested.

TOOLS

10	Awl, scratch
1 set	Bit; auger, #4 to #16
2 sets	Bit; drill, high speed, fractional, 1/8 in. to 1/2 in.
1	Bit; expansive, 7/8 in. to 3 in.
1 set	Bit; power bore, 3/8 in. to 1 in.
1 set	Bit; spade, 3/8 in. to 1 in.
5	Bit brace; ratchet, self-centering
2 each	Caliper; 6 in. adjusting, inside and outside
1 set	Cold chisel
2	Drill; hand, concealed gears, 1/4 in. chuck
5	File cleaner
Assortment	File; flat, round, square
20	Fusepuller; safety grip, 30A to 200A
1	Greasegun; manually operated
20	Hacksaw; adjustable, 12 in. with extra 32 t.p.i. blades
20	Hammer; claw, 16 oz. and 20 oz.

4 each	Hammer; ball peen, 4 oz. and 7 oz.
4	Hammer; soft face, 8 oz.
2	Holesaw; mandrel, 1 1/4 in.
20	knife; electrician's
20	Level; torpedo, 8 in.
2	Level; 24 in.
1 each	Micrometer; 0 to 1 in. and 0 to 25 mm
2 sets	Nut driver
3	Oilcan; lever type
20	Pliers; diagonal sidecutter, 6 in., insulated
20	Pliers, lineman's, 8 in., insulated
20	Pliers; needlenose, 8 in., insulated
20	Pliers; water pump, 8 1/2 in., insulated
20	Pouch; electrician's
5	Punch; center
20	Rule; extension zig-zag, wood, 6 ft.
20 each	Screwdriver; Phillips, #1 and #2
20 each	Screwdriver; standard, 4 in. x 1/8 in. and 4 in. x 1/4 in.
2 each	Snips; aviation, right cut, left cut, and straight cut
20	Soldering bit; point and fork, wirebrush and scraper

20	Soldering gun; Dual heat 240W and 325W, 120V
20	Soldering pencil
2	Square; combination, 12 in.
2	Square; Try, 8 in.
1	Stock and dies, pipe, 1/4 in. to 1 in.
2 sets	Tap and die
5	Wire gage; Standard American
20	Wire stripper; automatic
20	Wrench; adjustable, 4 in. and 6 in.
2 sets	Wrench; box, 3/8 in. to 1 in.
2 sets	Wrench; open-end, 3/8 in. to 1 in.
2 each	Wrench; pipe, 8 in. and 14 in.
2 sets	Wrench; socket, 3/8 in. square drive, 1/4 in. to 1 in.
1 set	Wrench; socket, 1/4 in. square drive, 3/32 in. to 1/2 in.

POWER TOOLS

1	Bender; conduit, hydraulic, 2-in. capacity.
1	Drill press
1	Grinder; bench type with rests and shields, 7 in.
2	Portable drill; variable speed, reversible, 1/4 in.
2	Portable drill, variable speed, reversible, 3/8 in.
1	Portable drill; variable speed, reversible, 1/2 in.

TEST EQUIPMENT

5	Ammeter; portable, 0 — 2.5 — 10-A AC
5	Ammeter; portable, 0 — 3 — 30-A DC
5	Capacitor tester
5	Continuity tester; battery type portable, buzzer and light
1	Dynamometer; DC
1	Demonstration meter; with scale 0 — 250-mA DC, 0 — 2.5-A DC, 0 — 25-V DC
1	Demonstration meter; scale; with scale, 0 — 250-V DC, 0 — 5-A AC, 0 — 250-V AC
1	Demonstration meter, with scale, galvanometer 50 — 0 — 50μA
2	Galvanometer; portable universal
3	Growler
2	Insulation tester (Megger)
5	Milliammeter; portable 0 — 250 — 1000-mA AC
5	Milliammeter; portable, 0 — 10 — 100 — 1000-mA DC
6	Multimeter; 20,000 ohms/volts
5	Ohmmeter; portable, 0 — 10,000 ohms
2	Oscilloscope
1	Prony brake; c/w torque scale and balanced pulley
2	Tachometer; hand-held
1	Tachometer generator

1	Test board; relay
20	Voltmeter; pocket type, 50 — 300-V
5	Voltmeter; portable, 0 — 2.5 — 25 — 250-V AC
5	Voltmeter; portable, 0 — 1.5 — 15 — 150-V DC
10	VOM; portable AC/DC
5	Wattmeter
1	Wattmeter; portable single-phase, 0.5/2.5-A, 50/120-V AC
5	Watt-hour meter

MISCELLANEOUS EQUIPMENT

2	Alternator; synchronous, three-phase, 100-W
1	Autotransformer
6	Base unit; c/w controls, switch, plugs, rheostat
1	Battery charger
1	Bench; conduit
2	Bench; electronics, heavy-duty, 60 in. x 33 in. x 36 in.
10	Bench; 2-student, 60 in. x 30 in. x 35 in.
1	Bench; teacher's demonstration, 96 in. x 33 in. x 36 in.
1	Board; control, DC
1	Board; experimental, 3-lamp, 6-terminal
1	Board; multispeed, three-phase
1	Board; reversing, three-phase

1 each	Board; starter: three-phase and single-phase
1	Board; trainer, motor control
20	Books; National Electrical Code
1	Cabinet; storage, instrument
1	Cabinet; storage, 96 in. x 14 in. x 36 in.
10	Capacitor; assorted size, 65-mfd — 650-mfd
2	Choke unit; 10 henries, 100-mA
1	Demonstrator; braking, DC
1	Demonstrator; electromagnetic brake, c/w pulley
1	Demonstrator; silicon bridge rectifier
1	Demonstrator; silicon half-wave rectifier
3	Fire extinguisher; Type ABC
1	First-aid kit; shop
2	Four capacitive unit; 2/0.25 — 1/0.5 — 1/1.0-mf
2	Generator; compound, 120-V DC, 100-W
1	Generator; demonstration
5	Generator; fractional horsepower (dynamo)
5	Generator; hand-operated
1	Inertia load; variable
1	Load control

1	Load; reactive, mobile, three-phase, 3000-V AC
1	Load; resistive, mobile, three-phase, 6.5KW
3 each	Load unit: reactive and resistive
1 set	Magnet; permanent, bar
1	Magnet; permanent, horseshoe, 3 in. x 5 in.
1	Magnetic compass
1	Motor; capacitor, fractional horsepower
1	Motor; capacitor start, 1/3 HP, 115-V AC
2	Motor; compound, 120-V DC, 100-W
1	Motor; display, cut-away
2	Motor; induction, fractional horsepower
2	Motor; polyphase, 1/3 HP, 208-V AC, 1725 RPM
1	Motor; repulsion-start induction-run, 1/3 HP, 115-V AC
1 set	Motor; selsyn
1	Motor; series, DC
1	Motor; shaded-pole
1	Motor; shunt, DC
1	Motor; split-phase, 1/3 HP, 115-V AC
1	Motor; squirrel-cage, fractional horsepower, three-phase
1	Motor; synchronous, three-phase

1	Motor; universal, 1/3 HP, 115-V AC/DC, 4000 RPM
1	Motor; wound-rotor, 1/3 HP, 208-V AC
10	Power supply; bench pack, 0 — 24-V, 10-A
1	Relay; electronic
1	Relay; photoelectric
1	Relay; time delay
20 each	Resistor; 1-W color-coded: 1 ohm, 10 ohm, 100 ohm, 150 ohm, 1000 ohm, 10K ohm, 1 megohm
1	Resistor; mounted, 50-W
1	Rheostat; mounted, 50-W
2	Rheostat; series field
1	Speed control unit; S.C.R.
1	Speed controller; wound-rotor
1	Starter; C.E.M.F.
1	Starter, manual, 3-and 4-point, 1/3 HP, DC
1	Switch; centrifugal, plugging and antiplugging
2	Switch; knife, D.P.D.T., on acrylic base
2	Switch; knife, S.P.S.T. on acrylic base
1	Switch; synchronizing
1	Synchro-Pair
2	Shunt; 1 — 10-A DC

2	Table; soldering, 48 in. x 48 in. x 35 in., c/w irons
1	Transformer; air core
1	Transformer; center-tapped
2	Transformer; current, 10-A/2.5-A AC
2	Transformer; current, 25-A/5-A AC
1	Transformer; dissectable
3	Transformer; experimental, single-phase
5	Transformer; isolation
1	Transformer; metal core
1	Transformer; multitap
5	Transformer, variable
3	Transformer unit; single-phase
1	Transformer unit; three-phase
5	Vise; machinist, 4 in.
1	Vise; pipe

SYLLABUS IN TRADE ELECTRICITY-ELECTRONICS

SECTION II: TRADE ELECTRICITY

UNIT II: RESIDENTIAL AND COMMERCIAL WIRING

CONTENTS

Unit II: Residential and commercial Wiring

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USING THE SYLLABUS

Although bound as one volume, the four units of the syllabus which comprise *Section II — Trade Electricity*, are semi-independent. They may, as indicated by the flow chart, be arranged in various sequences to meet the needs of the individual student and the area employment market. The publication is constructed so that units may be separated; those not offered in the school's program of instruction in trade electricity-electronics being placed at the back of a ring-binder.

The contents of each unit represents the minimum which should be taught in a broad but specific instructional area. It is expected that each teacher, with the aid of the advisory council and curriculum coordinator, will add to the depth and breadth of the contents whatever is needed for entry-level employment while developing a course of study based on the syllabus. To assist the teacher in this process, the units are organized in a three-column format — content, objectives, and teaching suggestions — with a resource list and suggested equipment list appended.

The first column lists content organized in a logical, though not necessarily teaching, sequence. The first task in developing a course of study based on the syllabus is to reorganize the content sequence into that which should be most effective. While some content naturally flows from and to other specific content, many items can be "shuffled" to fit the student's extant motivation and readiness.

The middle column contains the objectives of the content, expressed in terms of desired student performance. In industry, the competent worker, given an apprentice or new worker to train, judges both the development of the learner and the effectiveness of the instruction by whether the learner can perform the particular task. In teaching trade electricity, the industrially experienced teacher will instinctively use the same performance criteria in evaluating student progress. He should also use it as a guide to selecting probably successful teaching methods. The teacher should, then, write performance objectives for the course of study which clearly and concisely state *what* he intends to teach *before* developing lesson plans which state *how* he intends to do so.

The third column consists of suggested methods of teaching the content to attain the stated objectives. This listing is not to be considered as prescriptive; it is included to demonstrate the variety of methods available, and so, stimulate the individual teacher's ingenuity in employing various methods tailored to each of his various students.

The resulting course of study will need revision only as changes occur in the skills and knowledge required for entry into employment in the specialization studied. As such it serves as a basis for the lesson plans which must be continuously revised in order to provide each student with quality instruction.

Upon completion of this unit the student will be able to demonstrate the skills, work habits, and related knowledge necessary to entry-level employment in the residential and commercial electrical trades.

CONTENT	OBJECTIVES	TEACHING SUGGESTIONS
BLUEPRINT READING	*The student should be able to:* Identify and interpret commonly used architect's symbols.	Introduce symbols and languages and their uses, and compare with electrical symbols. Match symbols with actual devices. Use student-practice worksheets. Tour school plant, matching electrical fixtures with their symbols. Assign students to develop floor plans of home, using symbols for electrical installations.
◦ Working Sketches – Schematic	Identify a schematic diagram and commonly used schematic symbols.	Provide individual student worksheets for practice in identifying standard schematic symbols. Reinforce throughout the course.
– Wiring diagrams	Identify a wiring diagram and interpret information given.	Explain the techniques of drawing wiring diagrams.

	Prepare a wiring diagram from a schematic and additional physical location data.	Have each student prepare wiring diagrams from work sheets, and from a working layout.
▫ Plans	Develop a materials list from interpretation of prints.	Discuss a materials "take-off" sheet.
– Drawings	Locate outlets on a floor plan.	Have the students develop a materials list. Provide a floor plan worksheet.
– Title block	Interpret information given in the title block.	Use a transparency or chalkboard model of a title block. Have the students prepare a title block for a previously made practice drawing.
– Scale	Determine actual dimensions of an installation by use of the print scale.	Discuss the necessity of scale drawing. Compare the rule and the architect's scale.
	Draw a working sketch of a given plan to scale.	Use the overhead projector to demonstrate drawing to scale. Provide sheets for student practice. Have each student develop a scale drawing of the classroom and of a room at home.
▫ Cable Layout	Prepare a sketch showing the actual routing of cables and/or conduits, including number, type, and size of conductors, and type and size of conduit necessary to complete an installation.	Have the students plan a cable layout on a blank floor plan using information given on an electrical layout.

CONTENT	OBJECTIVES	TEACHING SUGGESTIONS
WIRING METHODS		
• Installation	*The student should be able to:*	
— Cable	Install a cable run to code standards given a layout and construction description and cable and fittings.	Review NEC Art. 310.
. Support		Have the students select and wire one of three cable jobs listed on the practice job sheets.
. Mechanical		Have students submit a written evaluation correctly stating five locations for a specific cable type.
— Conductors	Select proper size and type conductors, and determine the size of conduit, when given a statement of circuit requirements.	Review the method of converting conductor diameters to circular-mils.
. Selection		Clarify "Note 8," Tables 310-16 through 310-19, NEC.
		Work chalkboard problems on increasing conductor size.
		Introduce Tables 1-5, Chapter 9, NEC.
. Fishing	Fish and pull the required conductors for a circuit, given a specific conduit system.	Discuss general code application and correct terminology of commonly used fittings.
		Demonstrate "fishing" methods.
— Conduit and fittings	Install the required conduit run, given a layout and construction description, conductors and fittings.	Use transparency to introduce other systems of wiring.
		Organize students in pairs to practice installation of conduit system and pulling and wiring the circuit conductors.

	Install a circuit in flexible conduit, given a layout and construction description, conductors and fittings.	Introduce samples of conduits and appropriate fittings. Compare flexible conduit with BX. Review Table 350-3 of NEC. Have students practice wiring flexible metal conduit circuit.
– Overhead (Triplex)	Install an overhead circuit, given a layout and the required materials.	Refer to NEC Art. 225. Emphasize: – size dependence on span length – minimum clearances – NEC Art. 225-19(c) requirements for clearance from windows, porches, fire escapes – effects of weather Organize students by pairs to demonstrate selection of wire and wiring of overhead circuit to specifications.
– Underground . Direct burial . Conduit	Describe the correct methods for installation of underground circuits.	Emphasize the necessity of using only conductors or cables listed as underground use – trade letters "UF" – in Table 310-13. Refer to NEC Art. 339; Art. 300-5, exception #3; fill requirements for tables in Chapter 9.
◦ Terminations	Make proper splices and terminal connections as required by a given system of several conductors and devices.	Demonstrate proper use of – crimp tool – pressure tool – types of splices Have each student practice sample connections and splices.

CONTENT	OBJECTIVES	TEACHING SUGGESTIONS
		Lead students in listing jobs which require terminations.
◦ Equipment Grounding	*The student should be able to:* Properly bond to a good ground a given system consisting of cable, conduit, and metal enclosures.	Teacher-led discussion, including: – importance of all grounding – NEC Art. 250 – location of ground – grounding of conductor Have students draw a model showing bonding and grounding.
LOW VOLTAGE WIRING		
◦ Bell and Chime Installation	Install and wire a simple bell circuit containing one control station. Install and wire a two-tone chime circuit containing more than one control station. Define terms used in low-voltage systems. "Troubleshoot" any low-voltage system.	Illustrate on the chalkboard such components of low-voltage systems as bells, thermostats, and different wires. Illustrate the components of a two-tone chime system. Have students practice installation and wiring procedures as shown on job sheets. Demonstrate troubleshooting procedures. Distribute handouts listing task procedures.
◦ Transformers	Select the proper transformer for a given low-voltage system. Install and wire the transformer.	Demonstrate selection of appropriate box for different transformers and procedures for proper mounting. Have each student practice skills on mounting boards.

LIGHTING CIRCUIT INSTALLATION

∘ Wiring Method Selection — Nonmetallic — Armored	Select conductor size and wiring methods for any specified lighting circuit.	Review wiring methods as applied to lighting. Include: — locating — continuous duty derating — temperature limitations around housings
∘ Box Selection	Select proper size and type of box.	Demonstrate features of surface boxes. Introduce nonmetallic cable boxes and fixtures. Discuss the rule on grounding to alternate clamp screws. Explain the uses of plastic boxes for W/RX. Introduce NEC Art. 370 — rationale on sizing (Art. 370-6) — exceptions to code requirement — examples of typical deductions — "single strap" Distribute student-practice worksheet on Box Fill.
∘ Switching Circuits — Line Voltage	Construct a lighting circuit fed from a single-pole switch.	Display necessary hardware. Explain principles of hot and neutral wiring, and color codes.

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CONTENT	OBJECTIVES	TEACHING SUGGESTIONS
		Demonstrate: – connector installation – grounding – stripping for wirenuts and terminals – tightening of connectors onto cable Distribute student practice worksheets.
	The student should be able to: Construct a lighting circuit controlled from two points, which meets code standards.	Use overhead transparency to trace through a basic schematic for a 3-way circuit. Explain "go-betweens," the nomenclature of 3-ways, and the methods of differentiating 3-ways. Discuss color coding of circuit. Distribute practice worksheets as followup.
	Construct a lighting circuit controlled from more than two points, which meets all code standards.	Distribute task sheets. Explain common uses of multiple control. Compare with 3-way control. Distribute student-practice worksheets for drawing basic 4-way schematics.

	Select the materials and wire a lighting circuit containing two stations of control.	Describe the types of jobs where feed is used. Review Exception 2 to NEC Art. 200-7. Emphasize need to color-code leads to comply with code.
– Low-Voltage	Correctly select and install low-voltage switches, relays, and cable for control from one or more points of a given lighting layout.	Identify and explain the function of low-voltage equipment including: – where used – how wired into high-voltage circuits Using task sheets, divide the class into small groups to practice installation.
LIGHTING FIXTURE INSTALLATION		
• Type – Incandescent – Ionized gas . Fluorescent . Mercury vapor . Other	Select a lighting fixture of a type and wattage appropriate for a specified mounting height and type of occupancy.	Introduce the incandescent bulb, explaining sizes, varieties, and applications. Refer to the "Lighting Comparison Chart" and the L/W and bulb-life ratings. Introduce fluorescent tubes and ballast, explaining sizes, varieties, and applications. Introduce the mercury vapor lamp, explaining sizes and applications. Summarize applications and operating characteristics of various lamps. Review uses of metal halide and H.P. sodium lights.

CONTENT	OBJECTIVES	TEACHING SUGGESTIONS
		Tour school shop facilities to show various fixtures.
° Mounting	*The student should be able to:* Mount and securely support any specified incandescent or ionized-gas lighting fixture.	Introduce: – the photo cell control unit and its application to dusk-to-dawn control – lagscrew application – drip loop in O/D fixtures – turn-on procedure for photo cell Install and test lamp.
° Spacing	Layout lighting fixtures to optimal spacing, given the floor plan, lighting level, and description of occupancy.	Review load calculations (1500-W). Summarize available units (1x4 Troffer, 2x4 Troffer). Review: – other design criteria – planning for needs Have students layout hypothetical 4 ft. x 8 ft. rectangles and position lights on a provided plan, indicating the single-pole and 3-way switching. Provide students with alternate working plans.
° Light-Level Computations	Determine the light-level and power requirements for a given floor plan and description of occupancy.	Discuss the factors involved in determining light-levels. Using a transparency of the watts/sq. ft. table, demonstrate "rule of thumb" computations.

		Have students calculate: 15 — 2 x 40-W fixtures total load 1500-W (12.5-A) or 1 — 20-A circuit. Have students analyze and calculate a nearby room.
APPLIANCE CIRCUIT INSTALLATION		
◦ Type — Small appliance — Major appliance	Determine the characteristics of an appliance circuit needed to feed a described appliance.	Review NEC Art. 210-23 and 220-3. Demonstrate grounding of boxes and receptacles, and connections to white/silver terminals on demonstration board. Distribute job sheets to students for individual practice.
◦ Cable Selection — Armored — Metallic — Type SE	Select proper cable size and receptacle configuration, and correctly wire a 30-A or 50-A major appliance circuit.	Introduce "individual branch circuits." Use the demonstration board to show the proper location of "neutral and grounding" conductor. Introduce models of 30-A and 50-A cables and receptacles and discuss their characteristics. Distribute theory sheets on color-code circuits and task sheets for reinforcement practice.
◦ Split Circuits	Install a multiwire split appliance circuit.	Review trade terms such as branch circuit and multiwire. Introduce NEC requirements.

CONTENT	OBJECTIVES	TEACHING SUGGESTIONS
		Demonstrate: – differences in ground and neutral conductors – use of pigtails at first receptacle outlet – use of "neutral" Have students practice diagraming and wiring a circuit to specifications.
◦ Special Purpose Receptacles	*The student should be able to:* Select a receptacle suitable to the nameplate data of a given appliance.	Introduce NEC Art. 100 for clarification of types of appliances and branch circuits. Note Exception #1, Art. 210-4; Also Art. 210-23. Use a transparency and handout sheets to show NEMA configuration for general purpose wiring. Distribute worksheets requiring the student to determine size, type, and kind of conductors, and insert configuration of receptacle.
◦ Fixed Appliance Wiring – Oil burner – Water heater – Range	Install the branch circuit wiring required for a given layout and description of a fixed appliance.	Introduce NEC Art. 422 by sections. Use a transparency to show water heater circuitry. Introduce "off peak" metering. Introduce Note 4, NEC Table 220-19, regarding cooking units and wall ovens.

		Provide individual job sheets for student-practice of circuit in installation.
SERVICE ENTRANCE INSTALLATION		
◦ Calculations	Calculate net computed load of the general lighting load of a given plan.	Discuss trade terminology. Discuss types of occupancies and NEC interpretations. Review the principles of calculating floor areas, demand factors, and lighting load. Project a transparency of lighting specifications. Have students practice calculating the load. Distribute worksheets of a house layout for calculation practice.
	Calculate the major appliance load of a given house plan.	Present the principles of calculating total major appliance load — NEC Art. 220. Use transparency and student handouts in demonstrating calculation of: — major appliance circuits loads . portable . fixed . 120-V . 240-V — demand factors for . dryer . range . other Have students practice calculations from prints and transparency of specifications.

OBJECTIVES	TEACHING SUGGESTIONS
CONTENT	Develop worksheets giving specific job specifications. Have students figure loads.
The student should be able to: Calculate a heating/cooling load.	Use transparencies to aid a discussion of: – types of systems – nameplate data – demand factors – principles of calculating in compliance with NEC Art. 220 Project practice specification sheets. Lead group practice in calculating loads. Develop practice worksheets. Have students practice calculation skill individually.
Calculate motor loads.	Discuss: – types of motors – interpretation of nameplate data – principles of calculating in compliance with NEC Art. 220 and 430 Use transparencies to aid in demonstrating the calculation of the total motor load for a typical community building. Distribute job sheets of motor data. Have students individually practice calculating total loads.

	Calculate the derating by applying demand factor.	Demonstrate the procedures. Follow-up with student practice. Discuss compliance with NEC Art. 220.
▫ Type		
— Weatherhead	Select the proper type and size weatherhead for a given service. Install a mast weatherhead at an indicated location. Install a cable weatherhead at an indicated location.	Discuss, using transparencies to illustrate: — purpose of weatherheads — types . cable or pipe . clamped or threaded — factors which determine location — codes governing installation — NEC Art. 230 — relationship to location of drop attachment point Show slides or pictures of varieties of weatherheads used locally. Invite local utility representative to discuss local concerns and regulations. Have students list a number of local buildings which use specific types of weatherhead, and state reasons why the specific types were selected.
— Cable	Select the size, type, and kind of cable appropriate for a net computed load.	Using various sizes SE cable and transparencies of NEC Art. 310, demonstrate use of the code in determining cable types and sizes and conductor ampacity and size. Have students practice selecting proper cable for a typical job based on a series of net computed loads.

CONTENT

OBJECTIVES	TEACHING SUGGESTIONS
	Reinforce by distributing job sheets for practice installation of service entrance.
The student should be able to: Determine the length of cable (parallel conductors of same length) needed for a given installation.	Using the riser layout of a typical house, discuss the principles determining: – length of conductors for drip loop – height above meter enclosure – cable needed for meter connections – choice of parallel conductors – calculations based on typical riser layout – distance from meter to panel – cable for panel connections Distribute worksheets for practice calculation of cable length.
Determine the correct size and type of connectors and clamps needed for a given installation.	Discuss the features and demonstrate the use of various sizes and types of fittings such as: – water-tight – nonwater-tight – pipe size or K.O. size – bushing size – 1-hole and 2-hole clamps – fastening clamps Have students practice compiling materials lists for 100-A, 150-A, and 200-A service entrances.

	Construct a yard pole which meets all applicable standards.	Use transparency, slide, or photo illustrations of the yard pole in explaining its function. Describe and discuss: – drop attachments – load conductor to meter – meter – line conductor – custom line attachment – current transformer Have each student list the components needed for a yard pole and make a working drawing of its construction.
– Masts	Determine size and length of mast and cable or conductors (parallel conductors of same length) and the proper fittings needed for a given installation.	Project transparencies of NEC Art. 230-24 and Tables 3A and B utility company's requirements for overhead service, and service mast. Discuss: – description of and requirements for the mast – principles of determining the mast length – local utility requirements Distribute drawings showing various problems in mast installation. Have students make a list of components needed for each.
– Underground	Describe local utility procedures for installation of underground service.	Demonstrate: – installation of underground service – use of hydraulic bender Have students use provided worksheets to compile a materials list for a given job.

CONTENT	OBJECTIVES	TEACHING SUGGESTIONS
▫ Meter Cabinets	*The student should be able to:* Determine if a hub or cover is required and select the correct size.	Use transparencies to illustrate: – information required by application form – choice of fittings – procedures for mounting terminating wires
	Make service application to the local utility company.	
	Locate and install cabinet.	Provide equipment and material for student practice, both individually and in small groups.
	Determine the correct installation procedures for current transformer cabinets.	
	Determine need for anti-oxidant, and terminate conductors at meter lugs.	
▫ Service Panels	Identify major types of service panels.	Set up a model panel on a 2 ft. x 2 ft. – 3/4 in. plywood backboard. Discuss principles and application of service panels.
	Select a panel amperage and capacity appropriate for load calculations and cable layout.	Distribute equipment catalogs and student worksheets. Form students into small groups to practice selecting equipment for given load calculations.
	Locate and install a panel backboard and panel for a given residential service.	
	Identify proper installation of commercial service.	
▫ Overcurrent Protection		
– Fuses . Configuration	Identify by sight the different types and sizes of fuses, and describe the uses of each.	Use transparencies in discussing the types, sizes, and uses of fuses. Emphasize the performance characteristics of each.

. Performance characteristics		Form students into small groups for practice in selecting fuse protection appropriate to each of a variety of given situations.
— Circuit Breakers	Identify by sight the type and sizes of circuit breakers, and describe the uses of each.	Use models, cutaways, and exploded drawings in discussing: — purpose of circuit breakers in the system — where breakers are located — operation of breakers — purpose of ground fault interrupter — operating principles of GFI — types of GFI — installations requiring GFI's
. Types Instantaneous Inverse Definite time action	Install any given circuit breaker in conformance with code requirements.	Have students install C.B. and GFI protection in a service mock-up.
. Grounding and Bonding	Select size and type of grounding electrode conductor. Determine the need for and select appropriate grounding electrodes. Install grounding electrode conductor and mechanical protection — continuous loop, no splicing. Install bonding jumpers to all metal enclosures or raceways. Describe the correct procedure for bonding all metallic piping in the structure.	Use raceway models and transparencies and handouts of bonding procedures in demonstrating: — identifying, selecting, and installing grounding electrodes — grounding conduit into boxes, enclosures, and raceways — features of various types of grounding systems Form students in small groups for skill development practice.

CONTENT	OBJECTIVES	TEACHING SUGGESTIONS
• Subpanels	*The student should be able to:* Locate and install subpanels as required on a given plan.	Use handouts and models of subpanels and cable types in demonstrating correct procedure for installing subpanels and calculating size and type of cable. Have students practice subpanel installation.
SURFACE RACEWAY INSTALLATION		
• Selection	Select the surface raceway system appropriate to given building construction data and power requirements.	Using various raceway systems, demonstrate different types, sizes, and methods of installation.
• Layout	Layout and install the selected raceway system.	Have each student select and install a raceway which meets instructor's specifications.
EMT INSTALLATIONS		
• Fittings	Identify by sight each type and size of EMT in a given selection of fittings.	Identify and demonstrate the use of: – EMT couplings and connectors, by type and size – the 2-piece connector Demonstrate the proper method of installing fittings to EMT, boxes, and enclosures. Have students describe the application of each fitting type shown on a handout.

• **Bending**	Make back-to-back bends, a "3-bend" pipe saddle, and bends of 90°, when given a dimensional sketch, a length of EMT, and an EMT bender.	Demonstrate and explain the proper use of the EMT bender — both floor and hand-held methods. Have students practice stub bends of 90° and 45° to fit mock-up shown on practice dimensional sketches. Review instruction on stub and off-set bends. Demonstrate proper layout, measuring, and bending procedures for "back-to-back." Have students practice back-to-back bends to fit mock-up. Demonstrate layout, measuring, and bending procedures for "3-bend" pipe saddle. Have students practice skills using different size pipes and given dimensional sketches.
• Layout	Make a layout of an EMT system containing graduated conduit sizes, and junction and pull box sizes and locations, as required by given design criteria.	Distribute handout sheet of a room layout. Demonstrate the method of conduit and box layout, and calculations of conduit size. Distribute handout sheet of a different room layout. Have the students layout an EMT system to given specifications.

CONTENT	OBJECTIVES	TEACHING SUGGESTIONS
ELECTRIC HEAT INSTALLATION		
∘ Types — Baseboard — Unit — Radiant — Central	*The student should be able to:* Select heating equipment of a configuration appropriate to a given floor plan and description of furnishings. Install heating equipment at locations indicated on a given floor plan.	Use transparencies of a standard house plan and various electrical heating units, and sample heating units. Introduce each type of unit and discuss their applications and limitations. Distribute handout sheets of a standard house plan. Have students use wattage requirements to select appropriate types of unit, and sketch the locations on the handout plans.
∘ Heat Loss Computation	Compute the heat loss of areas to be heated, given the building plans and wall construction data.	Use a transparency of standard floor plan, copies of factor table, heat loss form and heat loss sample form to introduce heat loss theory and demonstrate computation formulas. Have students compute overall heat loss of their homes, room by room, assuming "standard" construction when built. Have them recalculate the computations on a basis of presently recommended insulation.
HEATING CONTROL INSTALLATION		
∘ Relays	Identify, by sight, samples of line-voltage thermostats and relays, and state their application.	Using handouts and transparencies of thermostat wiring, thermostats, relays, baseboard unit mock-ups, and code requirements, demonstrate line-voltage thermostat installation.

◦ Thermostats – Line-voltage – Low-voltage	Install selected circuits.	Compare low-voltage control with line-voltage. Demonstrate single-pole and extra connections for off-position relay function. Have students trace circuitry of a line-voltage thermostat on a wiring handout. Have students use mock-up models and worksheet layouts to practice wiring layout.
INTERCOM AND ALARM SYSTEM INSTALLATIONS		
◦ Intercom Circuits	Interpret the symbols used on a given layout of a typical intercom system. Install a typical intercom system.	Use transparencies and student handouts to introduce symbols used in intercom systems layout. Use a model to demonstrate the principles of an intercom system. Describe limitations and advantages of the various systems.
◦ Alarm Circuits – Closed – Open	Identify layouts as either fire, security, or combination alarm systems.	Distribute data sheets on typical security and fire alarm systems. Use a model to demonstrate the mechanics of an alarm system. Draw a typical layout pattern on the chalkboard. Have students interpret alarm wiring diagrams.

CONTENT	OBJECTIVES	TEACHING SUGGESTIONS
	The student should be able to: Interpret systems layouts and install the systems.	Demonstrate the proper methods of installing alarm systems components, including: – wiring methods and termination – multi-pair cable and 2-wire cable Form students into small groups to practice wiring and installation of alarm systems.
◦ Sensing Devices	Describe the appropriate device used to sense heat, smoke, or intruder.	Use a complete alarm system in demonstrating the function of each sensing device.
– Smoke		
– Heat	Identify and install the sensing device required by a given layout.	Discuss the advantages and limitations of each, and their circuitry layouts.
– Intruder		
REMODELING WIRING		
◦ Building Construction	Identify by name the different types of house construction shown in given sketches. Describe the wiring job involved in each type of construction.	Project transparencies of various house plans. Discuss the different principles and techniques necessary for rewiring older and modern buildings. Use cutaway frame models to demonstrate rewiring procedures.
◦ Supplemental Wiring	Add a supplemental load center to an existing service. Determine the correct size and number of additional circuits needed.	Demonstrate the layout of a load center, and method of determining the load, cable, wire size, and number of circuits. Have students practice wiring skills.

		Distribute practice worksheets giving a number of circuits. Have students compute load and wire size for a supplemental load center.
ELECTRICAL ESTIMATING		
∘ Material List	Prepare a materials and costs list from a given electrical layout.	Distribute practice worksheets and various electrical layouts. Have students prepare materials lists, using catalogs to obtain costs.
∘ Labor	Prepare an estimate of the total job labor cost, given a material list, sample layout, and an hourly rate of pay.	Discuss: – labor factors to be considered – industry standards Have students record time for completing classroom practice assignments. Labor cost will be estimated from this data. Distribute practice worksheets and electrical layouts and specs. Have students estimate labor costs.
∘ Overhead	List the factors that constitute business overhead.	Discuss such overhead items as property, liability, and unemployment insurance, Workmen's Compensation and health insurance, taxes, clerical salaries, and equipment maintenance and replacement. Provide sample overhead figures from actual jobs. Invite a local general contractor or independent electrician to discuss the overhead factor.

CONTENT	OBJECTIVES	TEACHING SUGGESTIONS
RELATED HARDWARE		
◦ Identification	*The student should be able to:* Identify by sight and describe the use of fasteners, clamps, straps, hangers, and other related hardware.	Use transparencies and models to introduce the varieties of related hardware as needed in electrical work.
◦ Selection and Use	Select and use related hardware as needed in electrical installations.	Demonstrate use of hardware when introduced.
RELATED EQUIPMENT		
◦ Hand Tools	Identify by name and state the uses of common electrician's hand tools.	Introduce tools as they are needed in electrical procedures so that students may practice manipulating and handling each of the tools in an actual application.
◦ Power Tools	Identify by name and state the use of common power tools. Demonstrate safe and workmanlike procedure in using hand and power tools.	Require each student to pass a written and practical safety test before using power tools. Test records should be kept on file.
◦ Test Instruments	Identify by name all common test instruments. Demonstrate safe and workmanlike procedure in using test instruments.	Introduce test instruments as they are needed in electrical procedures so that students may practice use in actual applications. Demonstrate the correct, safe procedure for using the test meter. As reinforcement and additional practice, have students use meters in various jobs and list all readings.

CODE REQUIREMENTS

∘ Type of Code – NEC – OSHA – Local – Other	The student should be: Aware of code requirements pertaining to electrical installations. Aware that there are several codes which must be adhered to. Acquainted with the penalties for violations. *The student should be able to:* Efficiently locate the section of a code governing a given situation.	Discuss: – reason for codes – source of authority – hierarchy of authority – interpretation – local characteristics
∘ Inspection Application	Complete the Board of Fire Underwriters application form.	Project transparencies and distribute duplicated samples of the application forms. Discuss information required, including the need to identify specific locations on the promises to be inspected. Clarify unusual terms such as rosette and pendant.
∘ Violation Notice	Interpret the Board of Fire Underwriters violation report. Determine what changes must be made to conform to the code.	Have students individually practice making inspection applications. Distribute practice worksheets stating violations. Have students identify the article and section of NEC covering the violations.

RESOURCE LIST

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Mullin, R. C. *Electrical wiring: residential;* 4th ed. Albany, NY. Delmar Publishers. 1973.

Pipe, Ted. *Basic electricity training manual.* Indianapolis. Sams. 1973.

Richter, H. P. *Practical electrical wiring.* New York. McGraw-Hill. 1972

Singer, Butrand, B. *Basic mathematics for electricity and electronics.* New York. McGraw-Hill. 1972.

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TOOLS AND EQUIPMENT

This listing contains only the tools and equipment considered essential to properly instruct a class-group of 20 students in *Residential And Commercial Wiring*. Items essential to other units of the trade electricity-electronics program, or useful but not essential to this unit, are not included. Items listed here which are also listed for other units should not be duplicated in the school supply unless the respective units are to be taught concurrently to different class-groups. Class-groups of more than 20 students will, of course, require a corresponding increase in the quantities suggested.

TOOLS

20	Electrician's Belt and Pouch, containing: Cable Ripper Continuity Tester Crimping Tool; Kline #1000/6-in-1, or equiv. Hammer; electrician's, 20 oz. Knife; electrician's, 3 blade Pliers; channel lock, 10 in. Pliers; diagonal cutting, 7 in., insulated Pliers; lineman's, 8 in., insulated Pliers; long nose, 7 in., insulated Rule; zig-zag, wood, 6 ft. OR Tape Measure; steel, 6 ft. Scratch Awl Screwdriver; #1 and #2 Phillips, 3/16 in. and 5/16 in. standard, 3/8 in. x 8 in. standard, 6 in. screwholding
2 sets	Auger Bits; 1/2 in. shank, 1/4 in. to 1-1/2 in.
2	Bit Brace; ratchet, 9 in. swing
1	Chalk Box; with chalk
2 sets	Chisels; wood cutting, 1/2 in. to 1-1/4 in.
1 set	Cold Chisels; 1/4 in. to 1 in.
2	Cutter; armored cable, roto split type
1	Cutter; tubing, 1 in. capacity (for demonstration)
2 sets	Drill Bits; carbide, 3/16 in. to 3/4 in.
1	Extender; auger bit, 12 in.
1	Extender; auger bit, 12 in.
Assortment	File: round, half-round, flat, triangular, mill and bastard cut
1 each	Fish Tape; 50 ft. and 100 ft.
1	Fish Tape; nylon, 50 ft.
2	Fish Tape and Wire Puller

1		Framing Square
4		Fuse Puller
2		Hammer, 36 oz.
1		Hammer; drive tool
4	sets	Hex Keys (allen wrenches); 1/32 in. to 1/2 in.
1	set	Holesaws; mandrel type, 1/2 in. to 2-1/2 in.
2	sets	Knockout Punches; 1/2 in. to 2 in.
1		Level; 24 in.
20		Level; torpedo, magnetic
2	sets	Nut Drivers; hollow shank, 3/16 in. to 9/16 in.
1		Pinch Bar; 24 in.
5		Pliers; slip joint, 6 in.
2	each	Pliers; vise-grip type, 6 in. and 10 in.
1		Plumb Bob
1		Pop Riveter
6		Punch; center
4		Reamer; pipe, straight flute, 1/2 in. to 2 in. capacity
10		Saw; hack, 12 in. frame
2		Saw; crosscut, 8 point
6		Saw; keyhole, 12 in.
2	each	Screwdriver; 1-1/2 in. length, 1/4 in. standard and #2 Phillips
1		Snips; aviation, left hand
1		Snips; aviation, right hand
1		Snips; aviation, straight cut
1	set	Socket Wrench; 3/8 in. drive, 3/8 in. to 1 in.
2	sets	Speed Bits; 3/16 in. to 1-1/2 in.
1	set	Tap and Die; bolt, 4-40 to 1/2 in. NC and NF
1		Tape Embosser
1		Tape Measure; 100 ft.
2	sets	Threaders; pipe, 1/2 in, to 2 in.
1	set each	Twist Drills; fraction, number, letter
4	each	Wrench; adjustable, 8 in. and 12 in.
4	each	Wrench, pipe, 12 in. and 16 in.
1	set	Wrenches; combination box and open end, 3/8 in. to 1 in.

POWER TOOLS

All electrically powered tools should be rated "Commercial Duty" or better

2	Electric Drill; portable, 1/4 in.
2	Electric Drill; portable, 3/8 in., variable speed, reversible

2		Electric Drill; portable, 1/2 in., reversible
1		Electric Hammer; 3/8 in.
1		Engraver; metal
1		Grinder; double 6 in. wheels
1		Saw; saber
1		Saw; reciprocal
5		Soldering Gun; 90-W/140-W
2		Soldering Iron; 47.5-W, with stand
1	each	Sterilizing Cabinet: goggles, helmets
1		Vacuum Cleaner; shop, with attachments

TEST EQUIPMENT

6	Ammeter; snap-on, multiscale
4	Flashlight; with continuity leads
1	Tachometer; hand held
4	Volt/Ohm Meter
20	Volt Tester; neon
4	Volt Tester; solenoid

MISCELLANEOUS EQUIPMENT

10		Bender; EMT, 1/2 in.
5		Bender; EMT, 3/4 in.
2		Bender; EMT, 1 in.
20		Goggles; safety
2		Ground Fault Interrupter; plug-in
20		Helmet; safety
4		Hickey; rigid, 3/4 in.
1		Ladder; extension, wood, 24 ft.
10		Ladder, step, wood, 4 ft.
2	each	Ladder; step, 6 ft., 8 ft., 12 ft.
1		Rack; conduit
1		Rack; wire, reel type
1		Scaffold; pipe frame, with casters, 12 ft.
4		Vise; machinists
2		Vise; pipe, quick release, 4 in. capacity, tripod

SYLLABUS IN TRADE ELECTRICITY-ELECTRONICS

SECTION II — TRADE ELECTRICITY

UNIT III: INDUSTRIAL ELECTRICITY

CONTENTS

Unit III: Industrial Electricity

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USING THE SYLLABUS

Although bound as one volume, the four units of the syllabus which comprise *Section II — Trade Electricity*, are semi-independent. They may, as indicated by the flow chart, be arranged in various sequences to meet the needs of the individual student and the area employment market. The publication is constructed so that units may be separated; those not offered in the school's program of instruction in trade electricity-electronics being placed at the back of a ring-binder.

The contents of each unit represents the minimum which should be taught in a broad but specific instructional area. It is expected that each teacher, with the aid of the advisory council and curriculum coordinator, will add to the depth and breadth of the contents whatever is needed for entry-level employment while developing a course of study based on the syllabus. To assist the teacher in this process, the units are organized in a three-column format — content, objectives, and teaching suggestions — with a resource list and suggested equipment list appended.

The first column lists content organized in a logical, though not necessarily teaching, sequence. The first task in developing a course of study based on the syllabus is to reorganize the content sequence into that which should be most effective. While some content naturally flows from and to other specific content, many items can be "shuffled" to fit the student's extant motivation and readiness.

The middle column contains the objectives of the content, expressed in terms of desired student performance. In industry, the competent worker, given an apprentice or new worker to train, judges both the development of the learner and the effectiveness of the instruction by whether the learner can perform the particular task. In teaching trade electricity, the industrially experienced teacher will instinctively use the same performance criteria in evaluating student progress. He should also use it as a guide to selecting probably successful teaching methods. The teacher should, then, write performance objectives for the course of study which clearly and concisely state *what* he intends to teach *before* developing lesson plans which state *how* he intends to do so.

The third column consists of suggested methods of teaching the content to attain the stated objectives. This listing is not to be considered as prescriptive; it is included to demonstrate the variety of methods available, and so, stimulate the individual teacher's ingenuity in employing various methods tailored to each of his various students.

The resulting course of study will need revision only as changes occur in the skills and knowledge required for entry into employment in the specialization studied. As such it serves as a basis for the lesson plans which must be continuously revised in order to provide each student with quality instruction.

Upon completion of this unit the student will be able to demonstrate the skills, work habits, and related knowledge necessary to entry-level employment in the industrial electricity trades.

CONTENT	OBJECTIVES	TEACHING SUGGESTIONS
RIGID CONDUIT SYSTEM INSTALLATION		
• Type		
– Metallic	*The student should be able to:* Determine the type of rigid conduit system required from given information on location.	Develop a series of field trips to local industrial locations. If possible, visit the site of a rigid raceway installation.
– Nonmetallic	Select components and properly install rigid conduit systems which meet all code requirements.	Project a series of slides showing rigid raceways installation practices. Have students compare rigid conduit with EMT installation. Distribute job sheets containing necessary information on a rigid conduit installation. Have students make a materials list for the type system required, and install a significant section.

◦ Condulets and Pull Boxes	Identify by sight, select, and install condulet and pull boxes.	Review EMT fittings, if previously taught. Introduce and identify rigid conduit system types of condulets and pull boxes. Compare the components of rigid conduit and EMT systems. Describe the uses of each rigid conduit fitting. Demonstrate the procedure for installing rigid conduit fittings and compare with EMT. Distribute worksheets depicting rigid conduit fittings and an incomplete system. Have students identify the fittings and indicate where they fit into the system to complete it.
◦ Hangers and Supports	Identify by sight, select, and install hangers and supports for a given rigid conduit system.	Use transparencies and models of each type hanger and support in introducing them at the time they will be used. Demonstrate the methods of installing such conduit supports as – hangers – two-hole and one-hole clamps – "J.B." clamps Emphasize the importance of using the proper hanger/clamp for the given area.

CONTENT	OBJECTIVES	TEACHING SUGGESTIONS
		Have students practice identification of clamps and installation methods using demonstration boards and mock-up systems.
◦ Bending – Hand	*The student should be able to:* Make various specified bends, given a length of rigid conduit and a rigid conduit bender.	Review EMT bending, if previously taught. Introduce the rigid benders, and demonstrate their use. Demonstrate methods of conduit layout for bending – floor and hand held methods. Note that the 3/4-inch EMT bender can also be used for 1/2-inch rigid conduit. Emphasize that all bends in rigid conduit will be in 10° segments when using the rigid benders. Demonstrate the procedure for making – 90° stub bends – 45° bends – "offset" bends Have students make bends to fit into mock-ups.
– Mechanical	Make various specified bends in rigid conduit by the mechanical method.	Demonstrate the mechanical method of bending rigid conduit. Distribute handouts on bending, not using the "hickey." Note that EMT can also be bent in this manner.

		Have students make bends by the mechanical method, to fit into mock-ups.
– Hydraulic	Make various specified bends in rigid conduit by the hydraulic method.	Demonstrate the hydraulic method, using bender, drawings, transparencies, and student handouts. Emphasize safety precautions. Have students make bends by the hydraulic method to fit into mock-up.
◦ Cutting and Threading	Cut, ream, and thread rigid conduit to given measurements and standards.	Introduce and demonstrate use of the pipe cutters and reamers. Introduce and demonstrate use of the pipe threader. Have students individually practice cutting, reaming, and threading 1/2-inch rigid conduit.
◦ Planning and Layout	Make a layout of a rigid conduit system which will require graduated conduit sizes, and which will specify junction and pull box sizes and locations.	Review EMT wiring if previously taught. Demonstrate the method of determining proper conduit size. Demonstrate on the chalkboard, the method of laying out a rigid conduit system for a single room. Provide worksheets for the students to individually identify specifications for conduit size, and lay out a system.

CONTENT	OBJECTIVES	TEACHING SUGGESTIONS
∘ Wire Installation – Fish tape and pullers – Lubrication	*The student should be able to:* Fish and pull conductors required for a given conduit.	Demonstrate methods of pulling conductors into a conduit system. Have students practice fishing and pulling in the mock-up system.
TRANSFORMER INSTALLATION AND WIRING ∘ Types – Single-phase . Autotransfer . Isolation – Polyphase	Install any given transformer.	Use a doorbell transformer and a disassembled isolating transformer, or transparency of same, to show transformer construction. Emphasize the importance of correct use of terms: – primary – secondary – coil – core – step-up – step-down – polarity Introduce or review NEC Art. 450 and 450-3. Introduce standard ASA marking of terminals "H" and "X." Note the increasing use of "dry-type" transformers. Introduce students to polyphase systems.

◦ Wiring Connections – Parallel operation – Wye – Delta – Open delta	Wire and connect a transformer as indicated on a given wiring diagram.	Cite exceptions to transformer wiring regulations, and other articles that govern additional requirements for specific transformer uses. Demonstrate the various methods of wiring transformer connections. Compare advantages and disadvantages of various interconnections. Distribute worksheets. Have students complete transformer connection diagrams. Provide configuration specifications for wiring of three single-phase transformers, interconnected. Distribute job sheets which require students to install various transformers in a circuit, to obtain reduced voltage.
◦ Transformer Vaults and Cabinets	State the purpose of vaults and cabinets and describe their construction.	Schedule a field trip to industrial locations, distribution centers, or a school plant.
POWER TRANSMISSION SYSTEMS	Describe the techniques of power transmission.	Introduce the various types of generators: – synchronous alternators revolving field revolving armature – induction alternators stator winding rotor winding – inductor alternators
◦ AC Generators	List the three main types of generator, describe their principles of operation, and compare their features.	
◦ Power Plant Wiring – Primary Cable		Describe the principles of operation of each.

CONTENT	OBJECTIVES	TEACHING SUGGESTIONS
◦ Unit Substation	*The student should be able to:* Describe the construction of unit substations.	Describe the types of substations found in the local area. Identify dangerous areas. Have students list danger areas found in and around the school plant.
◦ Primary Cable Wiring	State the principles of power transmission.	Discuss the methods of transmitting high voltages: — between points of usage — substation to power station — power station to power station Have students list the different methods of transmission.
◦ High-Voltage Metering	Describe the metering procedures for high voltages necessary to power transmission.	Distribute handout sheets on types of metering. Explain the methods of metering high voltages. Demonstrate readings on different meters.
POLYPHASE SERVICE INSTALLATION		
◦ Metering Equipment	Describe the metering systems used in high-voltage, polyphase service.	Project a transparency of a current transformer installation. Describe components of a typical industrial service of less than 600-V/more than 200-A. Demonstrate the functioning of CT while describing the principle of operation. *Caution!* Emphasize avoidance of open terminals.

◦ Disconnects	Describe the switches used in a high-voltage, polyphase service.	Discuss methods of disconnecting the service and overcurrent protection, including use of the ground fault interrupter. Describe the use of primary voltage.
◦ Wiring Components	Select connectors, terminals, "bugs," and other components, appropriate to a given polyphase service.	Visit the school switchgear room to observe the large disconnects and other components. Conduct a field trip to local industry or utility, to observe typical large metering and unit-substation installation with primary voltage service.
DISTRIBUTION EQUIPMENT INSTALLATION ◦ Feeder Ducts	List the different types of distribution equipment commonly used in local installations, and describe the features of each.	Discuss types of feeder ducts, including – under floor metallic raceways – cellular metal raceways – wireways – busways – trolleys
◦ Power Panels		Discuss power panels, including: – switchboard – panel board power lighting
◦ Subpanels		Lead students in a study of the distribution system and equipment used in the school plant.
◦ Plug-In Duct Systems		Schedule a field trip to an industrial plant to observe the distribution system and various types of ducts and power panels used.

RESOURCE LIST

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TOOLS AND EQUIPMENT

This listing contains only the tools and equipment considered essential to properly instruct a class-group of 20 students in *Industrial Electricity*. Items essential to other units of the trade electricity-electronics program, or useful but not essential to this unit, are not included. Items listed here which are also listed for other units should not be duplicated in the school supply unless the respective units are to be taught concurrently to different class-groups. Class-groups of more than 20 students will, of course, require a corresponding increase in the quantities suggested.

TOOLS

20	Electrician's Belt and Pouch, containing Continuity Tester Crimping Tool; Kline #1000/6-in-1, or equiv. Hammer; electrician's, 20 oz. Knife; electrician's, 3-blade Pliers; channelock, 10 in. Pliers; diagonal cutting, 7 in., insulated Pliers; lineman's, 8 in., insulated Pliers; long nose, 7 in., insulated Rule; zig-zag, wood, 6 ft. Scratch Awl Screwdriver; #1 and #2 Phillips, 3/16 in. and 5/16 in. standard, 3/8 in. x 8 in. standard, 6 in. screwholding
2 sets	Auger Bits; 1/2 in. shank, 1/4 in. to 1-1/2 in.
2	Bit Brace; ratchet, 9 in. swing
1	Chalk Box; with chalk
2 sets	Chisels; wood cutting, 1/2 in. to 1-1/4 in.
1 set	Cold Chisels; 1/4 in. to 1 in.
2	Cutter; armored cable, roto split type
1	Cutter; tubing, 1 in. capacity (for demonstration)
2 sets	Drill Bits; carbide, 3/16 in. to 3/4 in.
1	Extender; auger bit, 12 in.
1	Extender; power bit, 12 in.
Assortment	File: round, half-round, flat, triangular; mill and bastard cut
2 each	Fish Tape; 50 ft. and 100 ft.
1	Fish Tape; nylon, 50 ft.
2	Fish Tape and Wire Puller
1	Framing Square
4	Fuse Puller

2		Hammer; 36 oz.
1		Hammer; drive tool
4	sets	Hex Keys (Allen wrenches); 1/32 in. to 1/2 in.
1	set	Hole saws; mandrel type, 1/2 in. to 2-1/2 in.
2	sets	Knockout Punches; 1/2 in. to 2 in.
1		Level; 24 in.
20		Level; torpedo, magnetic
2	sets	Nut Drivers; hollow shank, 3/16 in. to 9/16 in.
1		Pinch Bar; 24 in.
5		Pliers; slip joint, 6 in.
2	each	Pliers; vise-grip type, 6 in. and 8 in.
1		Plumb Bob
1		Pop Riveter
6		Punch; center
4		Reamer; pipe, straight flute, 1/2 in. to 2 in. capacity
10		Saw; hack, 12 in. frame
2		Saw; cross cut, 8 point
6		Saw; keyhole, 12 in.
2	each	Screwdriver; 1-1/2 in. length, 1/4 in. standard and #2 Phillips
1		Snips; aviation, left hand
1		Snips, aviation, right hand
1		Snips; aviation, straight cut
1	set	Socket Wrenches; 3/8 in. drive, 3/8 in. to 1 in.
1	set	Socket Wrenches; hex wrench drive, 3/8 in. to 1/2 in.
2	sets	Speed Bits; 3/16 in. to 1-1/2 in.
1	set	Tap and Die; bolt, 4-40 to 1/2 in. NC and NF
1		Tape Embosser
1		Tape Measure; 100 ft .
2	sets	Threaders; pipe, 1/2 in. to 2 in.
1	set each	Twist Drills; fraction, letter, number
4	each	Wrench; adjustable, 8 in. and 12 in.
4	each	Wrench; pipe, 12 in. and 16 in.
2		Wrench; pipe, 24 in.
1	set	Wrenches; combination box and open end, 3/8 in. to 1 in.

POWER TOOLS

All electrically powered tools should be rated "Commercial Duty" or better

2		Electric Drill; portable, 1/4 in.
2		Electric Drill; portable, 3/8 in., variable speed, reversible

2	Electric Drill; portable, 1/2 in., reversible
1	Electric Hammer; 3/8 in.
1	Engraver; metal
1	Drill Press; 15 in., tilting table, 500-4500 RPM, with motor and controls
1	Grinder; double 6 in. wheels
1	Saw; hack
1	Saw; saber
1	Saw; reciprocal
10	Soldering Gun; 240-W/325-W
2	Soldering Iron; 47.5-W, with stand
1	Sterilizing Cabinet; goggles, helmets
1	Vacuum Cleaner; shop, with attachments
1	Wrench; torque, 12 in., 3/8 in. drive

TEST EQUIPMENT

6	Ammeter; snap-on, multiscale
4	Flashlight; with continuity leads
2	Tachometer; hand held
4	Volt/Ohm Meter
20	Volt Tester; neon
4	Volt Tester; solenoid

MISCELLANEOUS EQUIPMENT

10	Bender; EMT, 1/2 in.
5	Bender; EMT, 3/4 in.
2	Bender; EMT, 1 in.
1	Bender; hydraulic, EMT and rigid, 2 in. capacity
20	Goggles; safety
2	Ground Fault Interrupter; plug-in
20	Helmet; safety
4	Hickey; rigid, 3/4 in.
1	Ladder; extension, wood, 24 ft.
10	Ladder; step, wood, 4 ft.
2 each	Ladder; step, 6 ft., 8 ft., 12 ft.
1	Rack; conduit
1	Rack; wire, reel type
1	Scaffold; pipe frame, with casters, 12 ft.
1 kit	Torch; propane
4	Vise; machinist's
2	Vise; pipe, quick release, 4 in. capacity, tripod

SYLLABUS IN TRADE ELECTRICITY-ELECTRONICS

SECTION II — TRADE ELECTRICITY

UNIT IV: MOTOR CONTROLS

CONTENTS

Unit IV: Motor Controls

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USING THE SYLLABUS

Although bound as one volume, the four units of the syllabus which comprise *Section II — Trade Electricity*, are semi-independent. They may, as indicated by the flow chart, be arranged in various sequences to meet the needs of the individual student and the area employment market. The publication is constructed so that units may be separated; those not offered in the school's program of instruction in trade electricity-electronics being placed at the back of a ring-binder.

The contents of each unit represents the minimum which should be taught in a broad but specific instructional area. It is expected that each teacher, with the aid of the advisory council and curriculum coordinator, will add to the depth and breadth of the contents whatever is needed for entry-level employment while developing a course of study based on the syllabus. To assist the teacher in this process, the units are organized in a three-column format — content, objectives, and teaching suggestions — with a resource list and suggested equipment list appended.

The first column lists content organized in a logical, though not necessarily teaching, sequence. The first task in developing a course of study based on the syllabus is to reorganize the content sequence into that which should be most effective. While some content naturally flows from and to other specific content, many items can be "shuffled" to fit the student's extant motivation and readiness.

The middle column contains the objectives of the content, expressed in terms of desired student performance. In industry, the competent worker, given an apprentice or new worker to train, judges both the development of the learner and the effectiveness of the instruction by whether the learner can perform the particular task. In teaching trade electricity, the industrially experienced teacher will instinctively use the same performance criteria in evaluating student progress. He should also use it as a guide to selecting probably successful teaching methods. The teacher should, then, write performance objectives for the course of study which clearly and concisely state *what* he intends to teach *before* developing lesson plans which state *how* he intends to do so.

The third column consists of suggested methods of teaching the content to attain the stated objectives. This listing is not to be considered as prescriptive; it is included to demonstrate the variety of methods available, and so, stimulate the individual teacher's ingenuity in employing various methods tailored to each of his various students.

The resulting course of study will need revision only as changes occur in the skills and knowledge required for entry into employment in the specialization studied. As such it serves as a basis for the lesson plans which must be continuously revised in order to provide each student with quality instruction.

TRADE ELECTRICITY

UNIT IV: MOTOR CONTROLS

Upon completion of this unit the student will be able to demonstrate job-entry level knowledge and skills necessary to describe the purposes, principles, and use of motor controls; interpret and construct motor control circuit diagrams; interpret and apply code requirements; apply the theory of operation of motor deceleration devices; construct manual and automatic motor control circuits; select and connect circuit pilot devices, magnetic line voltage starters and their enclosures, reduced-voltage starters, multispeed controllers, and DC controllers; and select and connect various types of motor drives.

CONTENT	OBJECTIVES	TEACHING SUGGESTIONS
GENERAL PRINCIPLES		
◦ Manual Controls	*The student should be able to:*	
— Disconnect	List the common types of manual disconnect, and describe the operation and state the purpose of each.	Acquaint the students with the NEC requirements for disconnects.
		Use manufacturers' catalogs as reference and for examples of types of disconnect.
— Thermal overload	Explain the principle of the thermal overload.	Demonstrate the operation of thermal overloads.
	Identify sample thermal overload devices by type, and state the principal uses.	Display samples of various types of thermal overload, relating each to industrial use.
		Use manufacturers' catalogs as reference, and for examples of types.

▫ Magnetic Controls		
– Control relays	Explain the principles of operation of magnetic control relays.	Explain the principles of operation.
. Voltage . Current	Identify sample control relays and state their purposes.	Demonstrate the operation of relays. Describe the uses of relays.
– Motor starter	Explain the principles of operation of a magnetic motor starter.	Project transparencies of illustrations of motor starters. Demonstrate the operation of a magnetic motor starter.
	Identify sample motor starters and state their uses.	Design an application which will demonstrate the function and use of motor starters. Be sure that the student fully understands such terms as line contacts, auxiliary contacts, holding contacts, and primary device.
– Overload relays	Explain the principles of magnetic overload relays.	Project transparencies of illustrations of overload relays. Cite NEC requirements for overload relays.
	Identify magnetic overload relays and state their purposes.	Demonstrate the operation of overload relays. Use manufacturers' catalogs as reference, and for examples of types of relays.

CONTENT	OBJECTIVES	TEACHING SUGGESTIONS
	The student should be able to:	
▫ Electronic Controls	Explain the principles of electronic motor controls.	Devise a demonstration which will show the differences between electric and electronic controls.
	Identify sample electronic controls and state the principal uses.	Describe the features of electronic controls and explain advantages and disadvantages.
MANUAL MOTOR CONTROL WIRING		
▫ Toggle Switch	Identify toggle switches.	Project transparencies of illustrations of symbols and diagrams.
	Describe the functions, operation, and common uses of toggle switches.	Demonstrate the operation of toggle switches.
	Construct a motor control circuit containing a toggle switch to operate a fractional horsepower motor.	Design an application which will demonstrate the function and use of toggle switches.
		Be sure that the student understands such terms as thermal protected and rating.
		Cite NEC requirements for toggle switches.
▫ Safety Switch	Identify sample safety switches by type.	Display various types of safety switches.
	Describe the functions, operation, and common uses of various types of safety switches.	Demonstrate the operation of safety switches and describe the principal uses.

	Construct a motor control circuit containing a safety switch as a means of disconnect.	Design an application which will demonstrate the function of safety switches. Be sure that the student understands such terms as rating, service duty, fusable, and non-fusable. Cite NEC requirements for safety switches.
◦ Drum Controller	Identify drum controllers. Describe the function, operation, and common uses of drum controller switches. Construct a control circuit containing a drum controller to manually operate a motor.	Project transparencies of illustrations of momentary-contact and maintained-contact drum controllers, internal switching diagrams, and symbols. Demonstrate the drum controller in manual operation of a motor. Cite NEC requirements for drum controllers.
AUTOMATIC MOTOR CONTROL WIRING		
◦ Float Switch	Identify float switches. Describe the function, operation, and common uses of float switches. Construct a control circuit containing a float switch to automatically control a motor.	Project transparencies of illustrations of float switches, diagrams, and symbols. Demonstrate the operation of a float switch circuit. Design an application—such as controlling pump motors or motor operated valves—which will demonstrate the function and use of float switches.

CONTENT	OBJECTIVES	TEACHING SUGGESTIONS
	The student should be able to:	
▫ Pressure Switch	Identify pressure switches.	Project transparencies of illustrations of pressure switches, diagrams, and symbols.
	Describe the function, operation, and common uses of pressure switches.	Demonstrate the operation of a pressure switch.
	Construct a control circuit containing a pressure switch to automatically control a motor.	Design an application—such as controlling an air compressor or water well pump—which will demonstrate the function and use of pressure switches.
▫ Temperature Switch	Identify sample temperature switches by type.	Project transparencies or illustrations of the various temperature switches, diagrams, and symbols.
	Describe the function, operation, and uses of each type.	Demonstrate the operation of the various types of temperature switches.
	Construct a control circuit containing the type of temperature switch required to automatically control specified motor-operated devices.	Design an application which will demonstrate the function and uses of various temperature switches.
▫ Hand-Off-Automatic	Identify hand-off-automatic switches.	Project transparencies of illustrations of hand-off-automatic switches, diagrams, and symbols.
	Describe the function, operation, and common uses of a hand-off-automatic switch.	Demonstrate the operation of a hand-off-automatic switch.

	Construct a control circuit containing a hand-off-automatic switch to control the function of a motor.	Design an application which will demonstrate the function and uses of hand-off-automatic switches.
MAGNETIC LINE VOLTAGE STARTERS		
◦ Sizes	Identify sizes of magnetic line voltage starters in accordance with NEMA standards.	Project transparencies of illustrations of sample sizes of magnetic line voltage starters.
	Describe the operation and uses of magnetic line voltage starters.	Demonstrate the use of tables to determine size of magnetic starters.
◦ Selection and Application	Select a starter and its enclosure for a specific application.	Have students use NEMA standards and tables to solve problems.
PILOT CONTROL DEVICE WIRING		
▫ Selector Switch	Identify component parts of a selector switch.	Project transparencies of illustrations of selector switches, diagrams, and symbols.
	Describe the function, operation, and common uses of selector switches.	Display types of selector switches and demonstrate their use.
▫ Pushbutton Station		
– Single station	Construct a 3-wire control circuit operated by a single pushbutton station.	Project transparencies of symbols and diagrams for single pushbutton station control circuit.
		Demonstrate construction of a 3-wire control circuit operated by a single pushbutton station, and describe its uses.

CONTENT	OBJECTIVES	TEACHING SUGGESTIONS
	The student should be able to:	
– Multiple station	Construct a control circuit containing multiple stations.	Project transparencies of symbols and diagrams for a multiple station circuit.
		Demonstrate construction and operation of control circuits containing multiple pushbutton stations and describe their common uses.
◦ Pilot Lights	Describe the use of indicator lights in a control circuit.	Project transparencies of symbols and diagrams of a control circuit containing indicator lights.
	Construct a control circuit containing indicator lights.	List the principal uses of indicator lights in control circuits.
◦ Timing Relays	Identify a timing relay.	Project transparencies of symbols and diagrams, and illustrations of types of relays.
	Construct a control circuit containing timing relays.	
	Demonstrate the adjustment of a timing relay.	Demonstrate construction of the control circuit and adjustment of the timing relay.
	Describe the common uses of timing relays.	
◦ Phase-Failure Relay	Identify a phase-failure relay.	Project transparencies of illustrations of phase-failure relays, symbols, and diagrams.
	Describe the function and operation of the phase-failure relay.	Review the hazards of phase failure.
	Construct a control circuit containing a phase-failure relay.	Demonstrate construction of a phase-failure relay circuit.

◦ Phase-Reversal Relay	Identify a phase-reversal relay.	Project transparencies of illustrations of phase-reversal relays, symbols, and diagrams.
	Describe the function and operation of a phase-reversal relay.	
	Explain the phase-failure protection operation of a phase-reversal relay.	Review the hazards of phase-reversal.
	Construct a control circuit containing a phase-reversal relay.	Demonstrate construction of a phase-reversal relay circuit.
◦ Limit Switches	Identify various limit switches by type.	Project transparencies of illustration of various types of limit switches, symbols, and diagrams.
	Describe the function and operation of limit switches.	
	Construct control circuits containing various types of limit switches.	Demonstrate the construction and use of a circuit containing a number of limit switches of various types.
REDUCED VOLTAGE STARTER WIRING		
◦ Resistive and Reactive Starters	Identify resistive and reactive starters.	Review code letters, locked-rotor current, full-load current, maximum allowable current, and torque.
	Describe the operational characteristics of resistive and reactive starters.	Have students mathematically solve problems of voltage drop, and resistance necessary for a specific motor.
	Connect a resistive or reactive starter to a three-phase motor.	Demonstrate connection of a resistive or reactive starter.
◦ Autotransformer Starters	Identify an autotransformer starter.	Review autotransformer operation and code regulations.

CONTENT	OBJECTIVES	TEACHING SUGGESTIONS
	The student should be able to: Describe the function and operational characteristics of autotransformer starters.	Demonstrate and compare the closed and the open transition wiring.
	Select tap connections for operating three-phase motors under various start/load conditions.	
	Make tap connections to three-phase motors operating under specific start/load conditions.	
▫ Part Winding Starter	Identify a part winding starter.	Project transparencies, or use other visuals, to illustrate three-phase motor wiring.
	Describe the function and operational characteristics of a part winding starter.	Review torque and dual-voltage motors.
	Connect a part winding starter to a three-phase motor.	Demonstrate connection of a part winding starter.
◦ Wye-Delta Motor Starter	Identify a wye-delta motor starter.	Review wye and delta wiring and the voltage and amperage of each type connection.
	Describe the function and operational characteristics of a wye-delta motor starter.	Project transparencies, or use other visuals, to illustrate the wiring connections of a 12-lead motor.
	Connect a wye-delta motor starter to a three-phase motor.	Demonstrate connection of a wye-delta motor starter.

MULTI-SPEED CONTROLLERS

▫ Separate Winding Starter	Identify a separate winding starter. Describe the function and operational characteristics of a separate winding starter. Connect a separate winding starter to a two-speed motor.	Project transparencies, or use other visuals, to illustrate how windings can be connected to create different sets of poles. Review the motor speed formula.
▫ Consequent Pole Starter	Identify a consequent pole starter. Describe the function and operational characteristics of a consequent pole starter. Connect a consequent pole starter to a multi-speed motor.	Project transparencies, or use other visuals, to illustrate the wiring of consequent pole starters. Demonstrate the connection of a consequent pole starter.

WOUND-ROTOR CONTROL WIRING

▫ Manual Speed Control	Identify manual speed controls. Describe the function and operational characteristics of manual speed controls. Connect a manual speed controller to a wound-rotor motor.	Review wound-rotor motor operation and wiring. Demonstrate connection of a manual speed controller.
▫ Automatic Speed Control	Identify automatic speed controls. Describe the function and operational characteristics of automatic speed controls.	Project transparencies, or use other visuals, to illustrate operation of a capacitor-timed frequency relay.

CONTENT	OBJECTIVES	TEACHING SUGGESTIONS
	The student should be able to: Connect an automatic speed controller to a three-phase motor.	Demonstrate connection of an automatic speed controller
SYNCHRONOUS MOTOR CONTROL WIRING		
◦ Pushbutton	Connect a pushbutton controller to a synchronous motor.	Review synchronous motor operation. Emphasize the importance of AC and DC connections, and sequence of operation. Demonstrate connection of a pushbutton controller.
◦ Automatic Time Synchronizing Controller	Connect an automatic time synchronizing controller to a synchronous motor.	Project transparencies, or use other visuals, to illustrate operation of out-of-step and polarized-field relays. Demonstrate connection of an automatic time synchronizing controller.
DIRECT CURRENT CONTROL WIRING		
◦ Manual Faceplate Starter		
– Three-point	Describe the operation of a three-point starter.	Review DC motor operation.
	Connect a three-point starter.	Demonstrate connection and operation of a three-point starter with open field protection.
– Four-point	Describe the operation of a four-point starter.	Emphasize the lack of open field protection.

	Connect a four-point starter.	Demonstrate connection and operation of a four-point starter.
° Manual Speed Control		
— Above-normal-speed	Describe the operation of an above-normal-speed controller.	Review DC motor operation.
	Connect an above-normal-speed controller.	Demonstrate connection and operation of an above-normal-speed controller. Emphasize safety regarding open field.
— Below-normal-speed	Describe the operation of a below-normal-speed controller.	
	Connect a below-normal-speed controller.	Demonstrate connection and operation of a below-normal-speed controller. Demonstrate connection and operation of a combination above-normal and below-normal-speed controller.
° Automatic Motor Control Wiring		
— Counter *emf*	Describe the operation of a counter *emf* controller.	Review wiring diagrams and symbols. Review DC motor operation. Review counter *emf*.
	Connect a DC counter *emf* controller.	Demonstrate connection of a DC counter *emf* controller.
— Voltage-drop acceleration control	Describe the operation of a DC lockout contactor.	Review voltage drop. Be sure that the student fully understands such terms as lockout and step-starting.

CONTENT	OBJECTIVES	TEACHING SUGGESTIONS
	The student should be able to:	
	Connect a voltage-drop acceleration controller.	Demonstrate the connection of a voltage-drop acceleration controller.
– Series relay acceleration	Describe the operation of a series lockout relay.	Demonstrate lockout relay operation.
	Connect a DC series lockout relay.	Demonstrate the connection of a DC series lockout relay.
DECELERATION CONTROL WIRING		
° Electric Brakes	Describe a typical electric brake mechanism.	Review electromagnetism.
		Demonstrate a motor operating with and without braking safety.
	Connect both AC and DC magnetic brakes.	Demonstrate connection of magnetic brakes.
° Dynamic Braking	Describe the operation of dynamic braking.	Design a demonstration, such as overlay transparencies to illustrate the operation of dynamic braking.
	Connect a dynamic braking circuit.	Demonstrate the connection and functioning of a dynamic braking circuit.
° Plugging (zero speed)	Define "plugging."	Be sure that the student fully understands such terms as zero speed, plugging, and anti-plugging.
	Identify a plugging switch.	
	Connect a plugging switch in conjunction with a reversing controller to stop a motor.	Demonstrate connection and functioning of a plugging switch.
		Explain and compare braking systems.

MOTOR DRIVES

- Belts and Pulleys

– Pulley ratios	Compute pulley sizes required for specified driver/driven speeds.	Demonstrate the relationship of sizes of driver pulley to driven pulley. Have students solve problems mathematically.
– Belt sizes	Measure belts to determine size. Determine belt size of existing installation by use of motor-to-machine formula. Select belts by size and code.	Demonstrate string method and formula method of determining belt length. Demonstrate use of size charts.
– Multiple belt drive	Select drive sets to meet torque and horsepower requirements. Install belts to appropriate tension. Describe the advantages and limitations of belt and pulley drives.	Explain the advantages of multiple belts. Demonstrate installation techniques.

- Flexible Couplings

– Selection . Rubber tube . Rubber-fabric disc . Steel disc . Universal disc . Universal type . Constant velocity	Identify flexible couplings by type, and describe their functioning. Select the proper coupling to meet specified needs.	Discuss and illustrate the features of various types of flexible coupling and describe their uses.

CONTENT	OBJECTIVES	TEACHING SUGGESTIONS
	The student should be able to:	
– Alignment . Thickness gauges . Dial indicators . Micrometers . Vernier calipers	Set up and align flexible couplings.	Demonstrate use of various instruments in setting up flexible couplings.
° Gear Motors	Identify gear motors.	Project transparencies of illustrations of various gear drives.
– Helical – Worm and spur – Right angle – Double reduction	Describe the functioning of a gear motor.	
	State the common uses of the gear motor.	Demonstrate the operation of various gear motor reduction devices.
° Variable Frequency	Explain the term "variable frequency."	Demonstrate the operation of variable speed drives in typical applications.
	Describe the operating characteristics of a variable speed drive.	Review alternator operation.
° Magnetic Clutches	Recognize the various types of magnetic clutch and state the common uses.	Project transparencies of illustrations of the various types of magnetic clutch.
	Explain the operation of magnetic clutches.	Demonstrate the operation of the various types of magnetic clutches, in typical applications.
° DC Variable Speed Control	Identify a DC variable speed control.	Project transparencies of illustrations of DC variable speed controls.
	Explain the function, operational characteristics, and uses of DC variable speed controls.	Review DC motor control.

	Connect a DC variable speed control.	Demonstrate the connection of a DC variable speed motor control in a typical application.
RELATED DRAWING		
° Symbols	Identify electrical symbols used in motor control diagrams.	Project transparencies of symbols with illustrations of the represented device.
– NEMA		
– ASA	Draw the symbol for any specified motor control device.	Display numbered motor control devices. Have students write the numbers on paper, then draw the symbol for the device bearing that number.
° Schematic Diagrams	Construct a schematic diagram from supplied specifications.	Be sure that the student fully understands such terms as line diagram, control circuit, and load circuit.
		Project overlay transparencies to illustrate construction of a schematic diagram.
		Demonstrate the electrical sequence method.
° Wiring Diagrams	Construct a wiring diagram from a schematic diagram.	Be sure that the student fully understands the terms panel diagram, and single line diagram.
		Demonstrate the physical location method.
° Target Table	Explain a sequence of operation by use of a target table.	Demonstrate the use of the target table in such applications as drum switch and motor driven timers.
	State the principal applications of target tables.	

CONTENT	OBJECTIVES	TEACHING SUGGESTIONS
CODE REQUIREMENTS	*The student should be able to:*	
° NEC	Locate within the various electrical codes the sections pertaining to motor controls.	Review the NEC, and OSHA and local codes, identifying sections regulating motor controls.
° NEMA		Introduce NEMA standards.
° OSHA	Interpret and apply regulations pertaining to motor controls.	
° Local		Demonstrate the procedure for efficiently locating specific sections of the codes.

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Buban, Peter & Schmitt, Marshall. *Understanding electricity and electronics;* 3d edition. New York. McGraw-Hill. 1975.

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National Fire Protection Association. *National electrical code.* Boston. The Association. 1975.

PERIODICALS

Electrical Construction & Maintenance. McGraw-Hill, P.O. Box 510, Hightstown, NJ. 08520.

Popular Electronics. 434 South Wabash Avenue, Chicago, IL. 60605.

School Shop. 416 Longshore Drive, Ann Arbor, MI. 48107.

Servicing. Howard W. Sams & Co., 4300 West 62d Street, Indianapolis, IN. 46206.

FILMS-FILMSTRIPS

National Electrical Association. 470 Atlantic Avenue, Boston, MA. 02210.

The electrician.

University of Illinois, Division of University Extension, Champaign, IL. 61820.

Electrical circuit faults; No. 51358

Electrical measurement; No. 58800

Electricity and magnetism—electric motors; No. 80832

TRANSPARENCIES

Keuffel and Esser Company, Educational Audio Division, 300 Adams Street, Hoboken, NJ. 07030.

Alternating current (sinewave)

3-M Business Products Sales, Inc., 141 East Main Street, Elmsford, NY. 10523.

Electricity and motors.

CATALOGS-AUDIOVISUAL

Hickok Teaching Systems, 2 Wheeling Avenue, Woburn, MA. 01801.

Modern Talking Picture Service, 1212 Avenue of the Americas, New York, NY. 10003.

National Audiovisual Center, National Archives and Records Service, General Service Administration, Washington, DC. 20409.

TOOLS AND EQUIPMENT

This listing contains only the tools and equipment considered essential to properly instruct a class-group of 20 students in *Motor Controls*. Items essential to other units of the trade electricity-electronics program, or useful but not essential to this unit, are not included. Items listed here which are also listed for other units should not be duplicated in the school supply unless the respective units are to be taught concurrently to different class-groups. Class-groups of more than 20 students will, of course, require a corresponding increase in the quantities suggested.

TOOLS

20	Electrician's Belt and Pouch, Containing: Fuse Puller; 30-A-200-A, with safety grip Hammer; electrician's, 20 oz. Knife; electrician's Level; torpedo, 8 in. Pliers; diagonal cutting, 6 in., insulated Pliers; lineman's, 8 in., insulated Pliers; needlenose, 8 in., insulated Pliers; waterpump, 8½ in., insulated Rule; zig-zag, wood, 6 ft. Screwdriver; #1 and #2 Phillips, 4" x 1/4" and 4" x 1/8" standard Wire Stripper; automatic Wrench; adjustable, 4 in. and 6 in.
10	Awl; scratch
1 set	Bit; auger, #4 — #16
2 sets	Bit; drill, high-speed, fractional sizes 1/8 in. — 1/2 in.
1	Bit; expansive, 7/8 in. — 3 in.
1 set	Bit; powerbore, 3/8 in. — 1 in.
1 set	Bit; spade, 3/8 in. — 1 in.
1	Bit Brace; ratchet, 9 in. swing
1 each	Caliper; 6 in., inside and outside

1 set	Cold Chisel; 1/4 in. — 1 in.
2	Drill; hand, concealed gears, 1/4 in. capacity
Assortment	File; flat, square, round
5	File Cleaner
20	Hacksaw; 10 in. — 12 in. adjustable, with extra blades 32 t.p.i
5 each	Hammer; ball peen, 4 oz. and 7 oz.
5	Hammer; soft face, 8 oz.
2	Holesaw; mandrel type, 1 1/4 in.
1 each	Micrometer; 0 — 1 in. and 0 — 25 mm
5 sets	Nut Driver
1	Pipe Stock and Dies; 1/4 in. — 1 in.
5	Punch; center
2 each	Snips; aviation, right, left, and straight cut
2	Spirit Level; 24 in.
2	Square; combination, 12 in.
2	Square; try, 8 in.
2 sets	Tap and Die;
5	Vise; bench, 4 in. jaws.
1	Vise; pipe
5	Wire Gage; Standard American

2 sets	Wrench; box, 3/8 in. — 15/16 in.
2 sets	Wrench; open end, 3/8 in. — 15/16 in.
2 each	Wrench; pipe, 8 in. and 14 in.
2 sets	Wrench; socket, 3/8 in. square drive, 1/4 in. — 1 in.
1 set	Wrench; socket, 1/4 in. square drive, 3/32 in. — 1/2 in.

POWER TOOLS

1	Conduit Bender; hydraulic, 2 in. capacity
1 each	Electric Drill; variable speed, reversible, 1/4 in., 3/8 in., and 1/2 in. capacity
1	Drill Press; 15 in., tilting table, 500 — 4500 RPM
1	Grinder; 7 in. wheels, with tool rests and shields
20	Soldering Bit; point and fork, with wire brush and scraper
20	Soldering Gun; 240-W — 325-W, 120-V
20	Soldering Pencil; 25-W

TEST AND ELECTRICAL EQUIPMENT

6	Base Unit; complete, with controls, switch, plugs, and rheostat.
10	Capacitor; assortment, 65 mfd — 650 mfd
5	Capacitor tester
5	Combination eddy current prony brake and tachometer, 0 — 2000 RPM
1	Combination prony brake and tachometer, 0 — 8000 RPM
5	Continuity tester; battery-type portable, with buzzer and bulb

2 Control; speed, SCR

1 Control; wound rotor (Equitech, or equiv.)

1 Demonstration meter, with scale; 0 — 250-mA DC, 0 — 2.5-A DC, 0 — 25-V DC

1 Demonstration meter, with scale; 0 — 250-V DC, 0 — 5-A AC, 0 — 250-V AC

1 Demonstration meter, with scale; galvanometer, 50 — 0 — 50-μA

1 Demonstrator; DC braking

1 Demonstrator; electromagnetic brake, with patch cords

1 Demonstrator; silicon bridge rectifier

1 Demonstrator; silicon half-wave rectifier

1 Generator; demonstration

5 Generator; fractional horsepower

3 Growler

1 Inertia Load; variable

- Modules

  2 AC/DC breaker, with pilot light, 3-pole, 10-A

  4 AC/DC overload (Equitech, or equiv.)

  5 AC magnetic contactor, with 4 N.O. and 4 N.C. contacts, 120-V AC

  2 AC relay, with DPDT relays, 120-V AC

  2 Adjustable time delay relay, with DPDT contact, 120-V AC coil

  1 CEMF relay, contact 120-V DC

  2 DC relay, with 2 DPDT relays, 120-V DC

2 Definite time delay relay, with 2 time delay relays, 120-V AC/DC

2 Drum controller

2 Meter, AC — 3 ammeters 0 — 0.5-A, 3 ammeters 0 — 5-A, voltmeter 0 — 150-V, wattmeter 0 — 750-W

5 Meter, DC — voltmeter 0 — 150-V DC with DPDT switch, ammeter 0 — 1 — 5-A, ammeter 0 — 0.5-A

6 Pushbutton, with 2 pushbuttons with N.O. and N.C. contacts and 2 pilot lights, 120-V AC/DC

2 Recycling timer, with 1 N.O. and 1 N.C. contact, 120-V AC

5 Selector/Toggle switch, with 2 selector switches and 2 toggle switches, 120-V AC/DC

1 Shunt field failure relay

1 Three-phase motor starting transformer, 208-V, 60 H_z

— Motors

2 Capacitor start, single-phase, 60 H_z, 1/3 HP, 115-V, 1725 RPM

1 Display, cut-away

1 Permanent split-capacitor, single-phase, 60 H_z, 1/3 HP, 115-V, 1725 RPM

1 set Selsyn

1 Split-phase induction, single-phase, 60 H_z, 1/3 HP, 115-V, 1725 RPM

2 Synchronous, three-phase, 60 H_z, 1/3 HP, 120/208-V, 1800 RPM

1 Universal, 1/3 HP, 115-V AC or DC, 5000 RPM

1 Wound rotor, three-phase, 60 H_z, 1/3 HP, 120/208-V, 1725 RPM

2 Motor/Alternator; three-phase, 60 H_z motor, 1/3 HP, 120/208-V, and three-phase, 60 H_z alternator, 1/3 HP, 120/208-V, 0.3-A 1800 RPM

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5	Motor/Generator; 1/3 HP, 135-V DC motor, and 115-V DC, 0.1 KW, 1725 RPM generator
6	Multimeter; 20,000 ohms/volts
5	Ohmmeter; portable, 0 — 10,000 ohms
2	Oscilloscope
—	Patch cord; 30-A banana plug and spade lug ends; 40 — 24 in., 25 — 19 in., 15 — 6 in
5	Power supply, input of 115-V AC, 15-A and output of 0 — 140-V DC/0 — 135-V AC, 10-A, 0 — 120/208-V AC, 5-A or 0 — 140-V DC, 10-A, 125-V DC, 0.75-A
1	Power supply; three-phase, 120/208-V, 5-A input and 120/208-V, fixed 5-A output
5	Relay; contactor, with 5 N.O. and 2 N.C. contacts, 120-V DC
20 each	Resistor; 1-W color coded: 1 ohm, 10 ohm, 100 ohm, 150 ohm, 1000 ohm, 10K ohm, 1 megohm
1	Resistor; mounted, 50-W
2	Shunt; direct current, 1 — 10-A DC
—	Transformer
	1 Autotransformer
	1 each Air core and metal core, center tap and multitap
	2 each Current, 25-A/5-A AC and 10-A/2.5-A AC
	5 Isolation
	5 Variable
	5 Control, input of 208-V AC, 100-VA and output of 120-V AC, 0.8-A
20	Voltmeter; pocket type, 50 — 300-V
1	Wattmeter; portable, single-phase, 0.5/2.5-A, 60/120-V AC

MISCELLANEOUS EQUIPMENT

1	Bench; conduit
2	Bench; electronics, heavy duty, 60 in. x 33 in. x 36 in.
1	Bench; teacher's demonstration, 96 in. x 30 in. x 35 in.
10	Bench; student, 2-place, 60 in. x 30 in. x 35 in.
1	Cabinet; instrument storage
1	Cabinet; storage, 96 in. x 36 in. x 14 in.
—	Fire extinguisher; Type B/C (Type A optional)
1	First-Aid Kit; shop size
1	Grease Gun; manual
3	Oil Can; lever type
2	Table; soldering, complete with irons, 48 in. x 48 in. x 35 in.